# DISTRIBUTION OF WATER
FROM
OPEN SPRINKLERS ON RIDGE POLES

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ARMOUR INSTITUTE OF TECHNOLOGY

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DISTRIBUTION OF WATER FROM OPEN SPRINKLERS ON RIDGE POLES

A THESIS

PRESENTED BY
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The writers are indebted to Mr. J. E. Evans of the Sprinkler Department of the Underwriters' Laboratories; to Mr. J. B. Finnegan, Professor of Fire Protection Engineering at the Armour Institute of Technology; and to Mr. N. F. Kimball, Instructor in Fire Protection Engineering at the Armour Institute of Technology, for advice and assistance in carrying out the work, freely sought and freely given.

INTRODUCTION.

The necessity for the installation of open sprinkler systems on roof ridge-poles as protection against exposing fire has long been recognized. Up to the time of beginning the investigation upon which this thesis is based, no important attempt had been made, so far as the writers have been able to learn, to determine experimentally what standards should be observed in the installation of such systems.

The object of this investigation was to devise an accurate and practical method for determining the exact conditions under which a ridge pole sprinkler system may be expected to give the most satisfactory service, and to derive specifications for a system using a given type of head, by means of this method.

The system should supply and distribute evenly over the roof surface the least amount of water which may be considered adequate for protection against exposing fire. The conditions under which an ideal distribution is

available probably differ for different styles of sprinkler head. In these tests the different available sizes of the Grinnell type of ridge-pole sprinkler head were used. The writers will endeavor to show in the conclusions drawn from these tests what should be the rules for installing heads of this type as regards size of head, position of the heads in respect to the roof and in respect to each other, the most effective water pressure to use, and other points bearing on the efficiency of the system which the tests may bring out.

It is the hope of the writers that work will be carried on in line with these investigations for the purpose of perfecting the method and determining the relative values of styles of head other than the one here used.

THE TEST APPARATUS.

The apparatus was designed to approximate the installation of a sprinkler head on piping fed by a pressure tank and supported in the usual manner directly above the ridge pole of a roof, with provision for collecting and measuring the water discharged from the sprinkler head. The water supply was furnished by apparatus which forms a portion of the permanent hydraulic test equipment in the Underwriters' Laboratories, and consists of a steel tank of 4500 gallons capacity, capable of holding 125 lbs. per square inch pressure. The tank is equipped with connections for receiving water from a 500 gallon per minute Quimby, electrically driven, rotary, fire pump; and air from a 50 ft., electrically driven, air pump. It also has a water gauge, pressure gauge, and valves for regulating discharge. The water pump draws water from a reservoir which is fed by the city water mains.

The roof surface was approximately plane, with a 1:4 pitch, making an angle of

26^{0} -33' with the horizontal.

The matter of a proper slant for this roof is more or less one of conjecture. The following paragraph from Vol. III, Kidder's "Building Construction and Superintendence", Page 87, applies to roofs of wood trusses, and in the same book it is stated that about the same rules hold for roofs with steel trusses. Kidder says:

"The most economical pitch for roofs supported by wooden trusses with horizontal tie-beams, is a rise of 6" to the foot, or approximately 26 degrees. This gives about the minimum of roofing material with a sufficient depth to the truss, and efficient resistance to the weather. For roofs supported by trusses of the scissor or hammer-beam type, the pitch should be 45 degrees or over."

Trusses of the scissors and hammer beam type are described in the same volume as being used for churches and other public buildings, of a type which would probably not be sprinkler equipped.

Observation by the writers, of roofs in service, bear out these statements, and in view of these facts, it is believed that tests run on a roof placed at this slant only, will be comprehensive enough to give results of value.

The roof was 16' long and 14' wide, a size which was found to be large enough to catch all appreciable water from the head. It was made up of four panels of 1 by 8 inch wood sheathing nailed on 2 x 4s, securely bolted together, and covered with one layer of composition tar and felt roofing paper, 30 inches wide, laid lengthwise of the roof, and nailed with each course lapped 6 inches over the next lower course. The surface presented by the roof was as regular as is ordinarily obtained in practice. The surface was divided by white painted lines into eight equal rectangular panels, to facilitate observing the distribution of water from the sprinkler head. At each of the two sloping edges of the roof was set up a deflector, made of building paper supported by thin boards, perpendicular to the surface of the roof and extending 18 inches above it,

to intercept water that would otherwise be thrown over these edges.

The height of these deflectors was chosen as that which would catch all the drops of water that would be effective on the roof, and was determined simply by the personal judgment of those conducting the tests.

The roof was supported at the top by a steel tank, and at the bottom and center by miscellaneous lengths of iron pipe, augmented by wooden wedges driven in to bring the various portions of the roof to proper elevation. Sliding was prevented by tie rods of iron pipe extending from points near the lower edge of the roof to the foundation of the tank, and securely fastened at these points.

The sprinkler heads used were Grinnell, diaphragm type, ridge pole sprinklers, of the following sizes: "1/4 inch, 5/16 inch, 3/8 inch and 1/2 inch". In each test the sprinkler head was installed at the exact middle of the roof, with the top of the deflector 4-3/4 inches above the ridge pole, at the end of a 4 ft. length of 3/4

inch pipe bushed to a 2 inch pipe leading from the pressure tank.

The sprinkler was placed at this particular height above the ridge pole because this is the normal height, when the head is installed in a 3/4 by 3/4 by 1/2 inch standard tee fitting, with the tee resting on the ridge pole.

The pipe line ran straight above the ridge pole for a distance of 8 ft. The 2 inch pipe contained a regulating valve, around which were placed two by-passes of 1-and 1/2-inch pipe respectively, each with a regulating valve, for regulating flows of various magnitudes with great precision. One foot from the end of the 3/4 inch pipe was a piezometer ring, to which were connected a 30 lb. and a 250 lb. gauge, by means of a patrol hose. The 30 lb. gauge was used for pressures within its scope, and the 250 lb. gauge for the higher pressures. Drain cocks were provided for carrying off leakage through the regulating valves when closed.

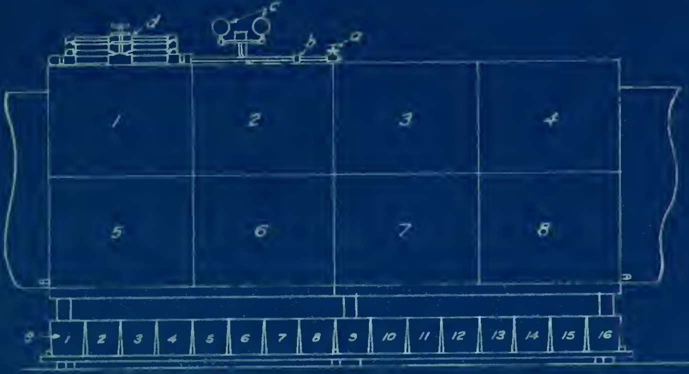
For the purpose of catching water flowing down the roof, galvanized iron pans were pro-

vided and arranged in a straight line under the lower edge of the roof. Each pan is approximately 1 ft. deep, with an open top 1 ft. square. Thus each pan catches the discharge over 1 ft. of the width of the roof. Two adjacent sides of each pan are extended about 1/2 inch above the top and bent over, forming a means of hooking the pans together and preventing loss of water in the space between pans. The pans are numbered for convenience, and are supported on planks to which are fastened wooden stops which facilitate alignment and insure placing the pans in the same location after each run.

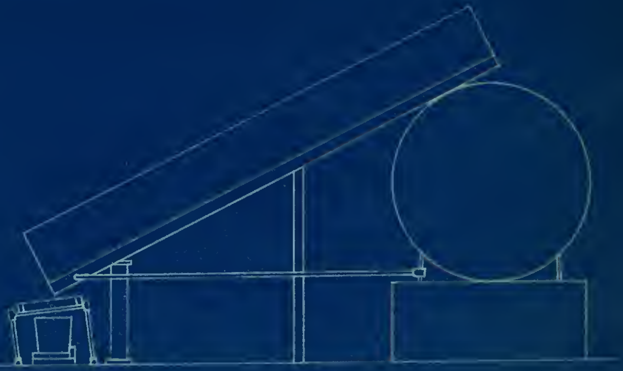
A covering was provided to keep water from falling into the pans except as desired. This covering was 3 feet wide and 18 feet long, and consisted of a wooden frame covered with roofing paper. It was supported by two iron stands, one at each end of the roof, with a slope from side to side of 1 inch to the foot, so as to shed water readily.

A beam scale of about 150 lbs. capacity and indicating weight to the nearest 1/2 ounce was used for weighing the pans and their contents. Time measurements were taken by the aid of an ordinary watch with dial graduated in minutes and seconds.

The depth of water on the roof was measured by means of a short, thin wooden measuring stick, of light color, and natural finish. This stick was held perpendicular to, and resting firmly on, the roof surface, with its edge facing up-stream. The height of the water mark at the downstream edge of the stick was taken to be very nearly the correct depth of the water. Depth could be measured to the nearest 1/32 inch in this manner.



Side view of apparatus, showing roof divided into zones; also, (a) sprinkler-head installed, (b) piezometer ring, (c) gauges, (d) by-passes with valves, and (e) pans.



End view of roof, showing method of support, and, at far end, deflector for preventing loss of water over edges; also, pans in position, with cover over.

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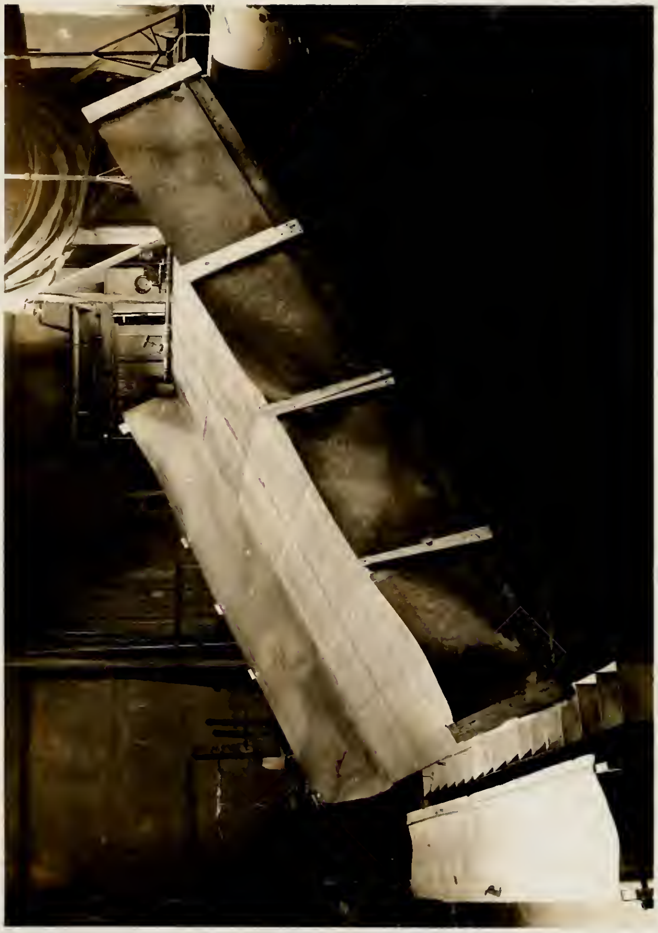
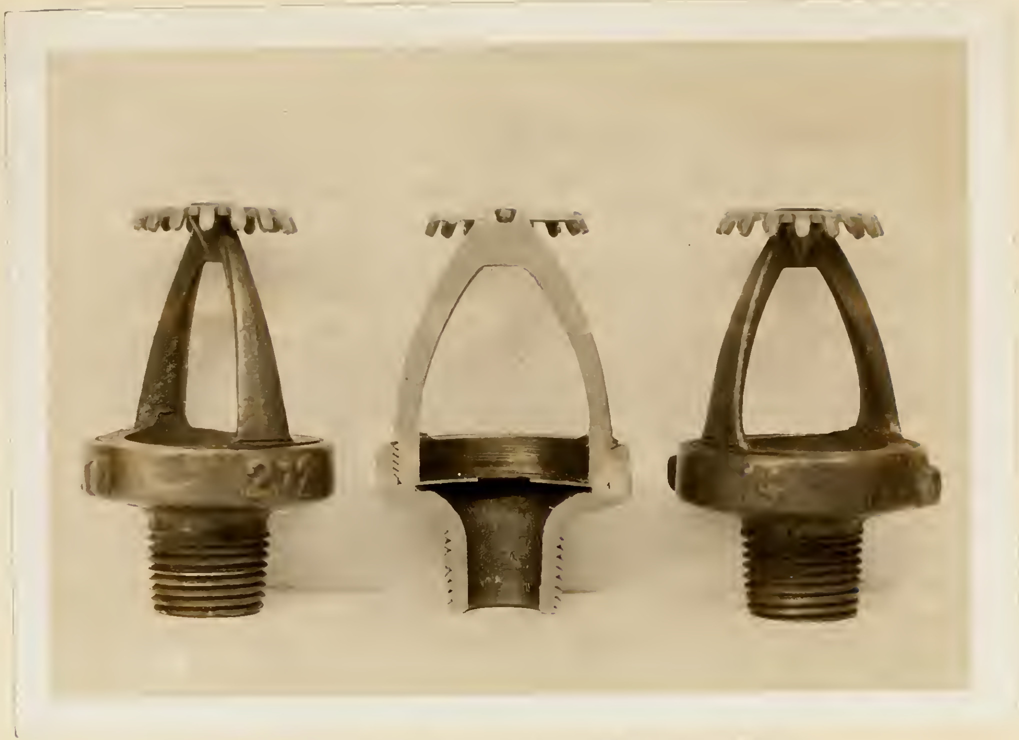


THE APPARATUS



Grinnell Open Sprinkler, Ridge-pole Type.
Full Views and Sectional View.

PRELIMINARY INVESTIGATIONS.

Before beginning the actual tests, several points concerning the position of an individual sprinkler in a ridge pole system were investigated, to decide how many positions of the head it would be necessary to consider for the purposes of this thesis. The points in question were as follows:

1.- Is the construction of ordinary tees such that a sprinkler connected to a pipe line by means of a tee will have its center line perpendicular to the center line of the piping? In other words, is the average tee accurately tapped and threaded for perpendicular connections?

2.- How close to the vertical can an average mechanic install a sprinkler when guided by his unaided eye.

3.- Would the maximum deviation from the vertical likely to occur on account of a mechanic being unable to judge the vertical by eye involve a difference in distribution great enough to necessitate taking complete sets of data with the head in both the vertical and the inclined position?

4.- At what height above the ridge-pole should the sprinkler be installed?

The answers to these questions were obtained in the following manner:

(1) A sprinkler was installed in a pipe line by means of twelve tees of the same type and dimensions, successively. The center line of head was found by means of a steel square to be perpendicular to the center line of piping in every case.

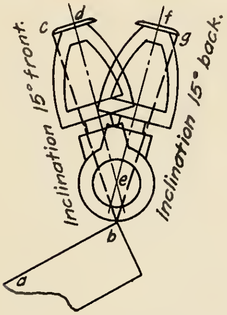
(2) Each member of the test squad in turn installed a sprinkler on a horizontal pipe, attempting to set the head vertical by eye. After each installation, the position of the head was tested by means of a spirit level and square. The results indicate that a mechanic would have no difficulty in installing a head within 5° of the vertical.

(3) The discharge over the roof surface from the 1/4 inch and 3/8 inch heads, first in the vertical position, and then inclined successively 15° to the front and 15° to the rear of a vertical plane through the ridge pole, was measured, at 15 lbs. and 100 lbs. service press-

ure. (See method under "The Standard Run", (Page 21). A comparison of the results obtained show that the difference in discharge under these conditions is negligible. Note that the angle of inclination was three times as great as the maximum angle of inclination assumed as a result of test in the preceding paragraph.

The figures on these tests indicate a condition, the existence of which may be questioned at first consideration. They show that the test roof surface, which is equivalent to one-half of an actual gable roof, receives a little less than one-half of the total sprinkler discharge, when the head is inclined 15° to the front so as to overhang the test roof surface, and a little more than one-half of the total, when the head is inclined 15° back; whereas the opposite results would be expected. The results as they stand are supported, however, by an analysis of the conditions in the vicinity of the sprinkler. If the axis on which the head rotates were coincident with the ridge-pole, the discharge would be divided equally at the ridge-

pole for all positions of the head. Since the axis is above the ridge-pole (Fig.I) the division of discharge is unequal. When the head is inclined to the rear, the roof surface "a b" receives one-half of the total discharge plus the water deflected into the space "b c d e", and when the head is inclined to the front, the roof surface "a b" receives one-half the total discharge minus the water deflected into the space "e f g b".



(Fig.I)

(4) The discharge from a 5/16 inch head at 75 lbs. flowing pressure was observed, first with the piping resting on the ridge-pole, and then with the piping raised enough to bring the deflector 1 foot above the ridge-pole. No material difference in the effective distribution of the discharge was noticeable. Therefore, it was decided that the sprinklers should be installed in the position which ordinarily involves the least expense; that is, in the posi-

tion in which the piping is most conveniently fastened to the ridge-pole.

METHOD OF PROCEDURE.

PRELIMINARY.

Selecting the heads.

The standard ridge pole type of Grinnell sprinkler head, manufactured by the General Fire Extinguisher Company of Providence, R.I., was used in all tests, in 1/4 inch, 5/16 inch and 3/8 inch sizes. In addition, a 1/2 inch head of the ridge pole type was improvised by substituting a deflector taken from a head of the standard ridge pole type for the smaller deflector on the ordinary 1/2 inch head.

The heads were selected from a number of the same type, care being taken to select those which were mechanically perfect, and otherwise in good condition.

Measurement of Pressure.

30 lb. and 200 lb. gauges were placed on a double fitting attached to the patrol hose. The low pressures were read on the 30 lb. gauge, and pressures from 50 lbs. up were read on the 200 lb. gauge. These gauges were calibrated each day that runs were made.

Establishing the Pressure.

Pressure was pumped up in the large pressure tank by means of either the Quimby pump, or the 50 ft. air pump, to a value slightly in excess of that needed at the head. The pressure was kept as nearly constant as possible by maintaining a relatively large volume of air in the pressure tank. It is found that best results are obtained with a volume of air twice that of water.

Velocity Factor Correction.

The diameter of the piezometer tube was measured, and the velocity correction calculated as shown in the sample calculations. A velocity factor correction curve was plotted.

Weighing the Pans.

The pans were wet thoroughly, and then drained and weighed, to give the weight to be subtracted from the total weight of pans and water. This weighing was repeated three times for each pan, and the average used.

Wetting the Roof.

The roof was wet down with a hose stream before each run, so that the distribution would be as even as possible. Runs were made to determine the time of wetting down the roof with water from the sprinkler head only. Time was taken from the instant water was turned on to the time when the middle sections were thoroughly and evenly wet.

Pressure Discharge Curves.

The total discharge from each head used was plotted against various pressures, from data supplied by the Underwriters' Laboratories.

THE STANDARD RUN.

The cover was placed over the pans, and when the proper pressure was obtained, the control valves were opened and the pressure adjusted to the desired value. The roof was wet down with the hose stream. After conditions had become settled, the cover was removed from the pans at a given instant, the time being carefully noted to the nearest second. The water was then

allowed to run for from two to five minutes, and the cover then replaced, the time being carefully noted. It was convenient to replace the cover on the even minute.

While the run was going on, observations of the following points were made:

1.- General distribution of water over the roof surface as judged by the eye.

2.- Thickness of the film of water in the middle sections of the roof.

3.- The estimated amount of water falling over the edge and sides of the roof.

4.- The amount of water thrown high in the air, and the probable effect of wind upon it.

5.- Miscellaneous points of interest which might occur in a test.

The pans were then each weighed separately, and their weight empty subtracted, to give the weight of water in each pan. Dividing this by the number of minutes the pan was exposed, and converting to gallons, gives the distribution in gallons per minute over each foot of the roof.

Distribution charts and pressure discharge curves were drawn, for each pan separately, and for the total amount of water collected.

The sum of the G.P.M.'s in each pan gives half of the total discharge of the sprinkler head, if the assumption is made that exactly one half of the water is thrown on the roof. While this ideal condition does not exist, it is found that comparing the total G.P.M. collected with the total discharge from the head gives a fairly close check on the correctness of the results. Hence this was done for each run, total discharge for each head at various pressures being obtained from the pressure-discharge curves.

RUNS MADE.

The following runs were made:

3/8" Head.

Head vertical, Arms perpendicular to Ridge,
(15-25-50-75-100# Pressure)

Head 15° to back, Arms perpendicular to Ridge.
(15-100# pressure)

Head 15° to front, Arms perpendicular to Ridge.
(15-100# pressure)

Head Vertical, Arms parallel to Ridge.
(15-25-50-75-100# Pressure)

Head Vertical, Arms perpendicular to Ridge.
(3' pipe extension beyond head.)
(15-100# pressure)

Head Vertical, Arms perpendicular to Ridge.
(Head installed in ell fitting)
(Visual observations)

Head Vertical, Arms perpendicular to Ridge.
(Head raised 12" above ridge)
(Visual observations).

5/16" Head.

Head Vertical, Arms perpendicular to Ridge.
(15-25-50-75-100# Pressure)

Head Vertical, Arms parallel to Ridge.
(15-25-50-75-100# Pressure)

1/4" Head.

Head Vertical, Arms perpendicular to Ridge.
(15-25-50-75-100# Pressure)

Head 15° to back, Arms perpendicular to Ridge.
(15-100# Pressure)

Head 15° to front, Arms perpendicular to Ridge.
(15-100# Pressure)

Head Vertical, Arms parallel to Ridge.
(15-25-50-75-100# Pressure)

1/2" Head.

Head Vertical, Arms perpendicular to Ridge.
(15-100# Pressure.)

Several Check Runs, with different heads.

Data, curves and notations were tabulated.

ACCURACY OF THE RESULTS.

Under this heading will be discussed several points with reference to the results, which have a bearing on their reliability.

The accuracy of the method of measuring the discharge will be first considered. The weights of the pans and the water contained in them could be easily obtained correct to the nearest ounce by the method of weighing used, and the percent of error is expressed by the relation $\frac{ex100}{16xP}$, where e is the deviation from the actual weight in ounces, and P is the weight of pan plus water in pounds. Assuming a deviation of 1 ounce per pan in the same direction in every case, the percent of error in measuring the total discharge during a complete run would be $\frac{16x1x100}{16xP'}$, where P' is the combined weight of water and pans. The minimum value of P' was 210 lbs.; hence the maximum error in weighing was probably around one-half of one percent.

The distribution charts show some conditions which require explanation:

1.- In every case there is a decided peak in discharge at the middle of the roof. Pans 8 and 9 received on the average about 3/2 as much water as pans 7 and 10. The reason for this may be readily understood by considering the discharge over zones, each one foot in width and bounded by circles concentric with the sprinkler head. The intensity of discharge is greatest in the zone nearest the sprinkler head, and diminishes as the radius is increased. Pans 8 and 9 receive all of the water that falls in the zone of heaviest distribution, and, in addition, water from each of the other zones. The other pans receive water from rapidly diminishing zone areas and intensities. The distribution could undoubtedly be improved by changing the design of the head so that more water would be thrown to the right and left than to the front and back, respectively.

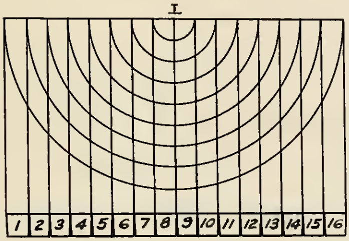


Fig. 2

2.- The discharge into pan 7 was less than that into pan 6, in nearly every case, whereas it would be expected to be greater. On the diagram of the apparatus (p.11),note that the piezometer ring "b" is in such a position that part of the water directed toward the strip of roof that leads to pan 7 is intercepted by the piezometer ring. The patrol hose attached to the piezometer ring extends downward behind the ridge-pole, and a large proportion of the water which strikes the piezometer ring is carried down the patrol hose by adhesion, and is lost.

3.- The discharge into pan 8 was less than that into pan 9, whereas it seems that it should have been the same. Observation of the sprinkler in action gave a distinct impression that more water is thrown to the right of the sprinkler (see p.11) than to the left; therefore pan 9 should show a greater discharge than pan 8. It was found that this condition was remedied somewhat by using a length of pipe beyond the tee (see chart C 51), and that the substitution of an ell for the tee made no

material difference (as noted by visual observation). The reason for this inequality of distribution is obscure, but it is probably due to the reactions that accompany the changes in direction of water passing through the tee.

An additional reason for the loss of water in pan 8 is that part of the water that should be carried to it strikes the piping, and is carried along the piping by its velocity until it strikes the piezometer ring, from which it runs down the patrol hose.

The loss of water down the patrol hose appears to have been as great as 5% of the total discharge in many cases. This is reasonable on account of the size of the piezometer ring and its nearness to the sprinkler. The location of the ring as it was during these tests therefore must be looked upon as a distinct flaw in the arrangement of apparatus.

It is suggested that for future tests along these lines the piezometer ring be

installed at a distance of at least 4 ft. from the sprinkler, and that the system piping be continued for at least 4 ft. beyond the sprinkler, so that all of the piping effects would be equal on both sides of the head, as would be the predominating case in an actual installation.

CONCLUSIONS.

DISCUSSION:

The conclusions consist of opinions formed by general observation during the tests, and those formed by a careful study of the notes on distribution together with a consideration of the discharge curves and charts. The results of general observation have been discussed, and will appear again in the summary. The pressure-discharge curves show nothing of importance beyond the fact that as the service pressure is increased the discharge per pan is increased at a uniform rate. The discharge charts, by virtue of their number, carry enough weight of evidence to establish definitely these two points:

1.- Within the range of inclinations to the vertical at which ridge-pole sprinklers are likely to be found in actual practice, the inclination does not materially affect the effective distribution of the discharge.

2.- The distribution is better when the arms are in a vertical plane through the ridge-pole

than when they are perpendicular to that plane. The discharge is more concentrated in the zone that extends 4 feet on either side of the middle of the roof, and is more evenly distributed.

In addition, the discharge charts furnish material from which a table may be compiled, showing:

1.- The probable minimum discharge in gallons per minute per foot length of roof, over any section of the roof, for each head, each pressure, and each spacing considered.

2.- The average distribution in gallons per minute per foot length of roof.

3.- The ratio of the minimum to the average distribution.

We shall here show why this table is of considerable importance. The duty of a ridge-pole sprinkler system is to keep the roof covered with water and thereby prevent its ignition by heat from an exposing fire. As long as the roof surface is covered with water, its temperature cannot rise above the boiling point. The tendency of an exposing fire is to evaporate

the water, and the rate of evaporation depends upon the area of surface exposed rather than upon the thickness of the sheet. If the velocity of water on the roof were high, the thickness of the sheet would be smaller for a given quantity of flow than if the velocity were low, but the rate of evaporation would be the same, and the thinner sheet, involving the same quantity of water in a given time as the thicker one, would be quite as effective as the thicker. The system, to be effective without aid from outside sources, must deliver water to every point on the roof as rapidly as it is evaporated therefrom, and the effectiveness of the entire system may be measured by the effectiveness at the weakest point.

Consider a number of sprinklers to be discharging water to a roof simultaneously at the same pressure. If a longitudinal section of the roof surface be represented by a straight line and the discharge per unit length of roof be represented by perpendicular distances to the

line at successive points, a discharge curve will be obtained as shown in Fig. 3.

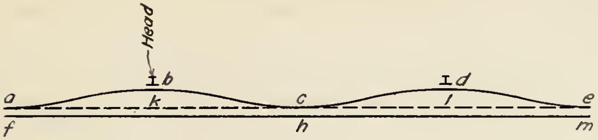


Fig. 3.

Points on the roof surface which are equidistant from two sprinklers will receive the least amounts of water, and therefore will be in greatest danger of ignition. To be completely effective in itself, the system must supply enough water to these points to withstand the exposure. Hence, it is important to know the minimum quantity of water which the roof will receive at any section under a given set of conditions.

The areas "a b c k a" and "c d e l c" represent water which is displaced from the points of least protection. While this water

would have some value as a fire stop in actual practice, it is well to consider it as water wasted, for the purposes of comparing the distribution from two sprinklers. Then for these purposes the ratio of area "a k c h f" to area "a b c h f" may be taken as representing the percentage of water effective as a fire stop. In other words, the ratio of the minimum discharge to the average is a measure of the percentage of water effective as a fire stop.

The table on page 39 shows the following data for each size of head, each spacing of head, and each service pressure considered:

1.- The minimum share of the total discharge in gallons per minute per foot length of roof, which any one-foot section of roof would be likely to receive.

2.- The average share of the total discharge which the one-foot sections would probably receive.

3.- The percentage of the total discharge effective as a fire stop.

The Table was compiled by the following method.

The effect of spacing heads 8 ft. apart was determined by adding together the discharges in pans 4 and 5, 12 and 13, 3 and 6, 11 and 14, etc. The minimum resultant G.P.M. was tabulated.

The effect of spacing heads 6 ft. apart was determined by adding together the discharges in pans 5 and 6, 11 and 12, 4 and 7, 10 and 13, etc.

The average discharge under each of the two spacings was found by dividing the total discharge by 8 and 6, respectively.

The loss of the water intercepted by the piezometer ring, as discussed on Pages 27-28 makes the figures for the average discharge a little smaller than they actually should be, but does not affect the minimum discharge, inasmuch as pans 7 and 8 are in no case in the minimum discharge zone. The loss does not detract materially from the value of the table ,

for whatever error is involved is on the side of safety, and the results as obtained are closer to the actual than it is possible to estimate the requirements.

The 1/2 inch head is not included in the table, because the two runs made with that head demonstrated conclusively that the head throws its discharge over too great an area to be effective as a ridge-pole sprinkler.

At 75 pounds and 100 pounds service pressure, the discharge, in the majority of cases, was broken up into fine spray at the deflector. The effect of wind on this fine spray would probably be to impair the distribution excessively. The items in the table which refer to conditions where fine spray was involved are marked with an asterisk (*).

The table shows clearly that the effectiveness of a ridge-pole sprinkler system may be nearly doubled by spacing the heads 6 ft. apart instead of 8 ft. The 1/4 inch head gives a poor distribution, and therefore is not particu-

larly adaptable to ridge-pole use. The best all-around performance is given by the 3/8 inch head at 50 lbs. service pressure.

By the aid of the table the size and spacing of head for a given installation may be selected to meet the estimated requirements of the probable exposure.

SUMMARY.

1.- Ridge-pole sprinkler systems may be installed with the piping at the most convenient distance above the ridge-pole, so long as the distance from the ridge-pole to the deflector does not exceed 1 ft.

2.- The average mechanic can install an open sprinkler as close to the vertical position as is necessary, using ordinary tees and ordinary precautions, provided the piping is level.

3.- The distribution from a ridge-pole sprinkler could probably be improved by changing the design so that more water would be thrown to the right and left than to the front and back.

4.- The heads should be installed with the arms in a vertical plane passed through the ridge-pole.

5.- The spacing of heads should be 6 ft. center to center.

6.- The table, referred to on Pages 31-37 appears with explanatory notes on the following page.

TABLE I.

The figures in columns headed "Min." show in each case the minimum share of the total discharge from a ridge-pole sprinkler system having the size and spacing of heads indicated, which any one-foot section of a roof having a 1:4 pitch and equipped with the system would be likely to receive. The values are given in Gallons per Minute per Foot Length of Roof.

The figures in columns headed "Ave." show in each case the average share which the one-foot section would receive under the same conditions.

The figures in columns headed "% Eff." show in each case the percentage of a sprinkler discharge which may be considered effective as a fire stop for purposes of comparing the performance of heads under varying conditions, as discussed on Pages 33-34.

Size of Sprinkler Orifice.	Spacing of Heads.	Min.	Ave.	% Eff.	Min.	Ave.	% Eff.	Min.	Ave.	% Eff.	Min.	Ave.	% Eff.	Min.	Ave.	% Eff.
1/4"	8'	.15	.26	58	.20	.39	51	.22	.55	40	.27	.66	41	.36*	.76*	47*
1/4"	6'	.19	.35	54	.29	.51	57	.42	.74	57	.60	.89	67	.74*	1.02*	72*
5/16"	8'	.19	.45	42	.25	.61	41	.37	.84	44	.50	1.02	50	.50*	1.19*	42*
5/16"	6'	.38	.60	63	.56	.82	68	.90	1.12	80	1.20	1.37	88	1.45*	1.58*	92*
3/8"	8'	.31	.64	48	.44	1.02	43	.57	1.25	46	.74*	1.56*	47*	.74*	1.74*	43*
3/8"	6'	.55	.84	65	.86	1.37	63	1.52	1.67	91	1.98*	2.08*	95*	2.32*	2.32*	100*
Pressure			15#			25#			50#			75#			100#	

N O T E: Items marked (*) refer to conditions where the sprinkler discharge was a fine spray.

The reader is reminded that the percentages given were obtained from theoretical considerations, and that the "100% Effective" item obtained in one case should therefore not be taken too seriously. The percentages given, however, serve as a convenient index for showing the relative effectiveness under different conditions.

DATA

DISCHARGE TESTS.

DATA.

Size of Orifice.	Corrected Pressure.	Discharge in G.P.M.
1/4"	99	11.38
	75	9.95
	50	8.05
	23	5.44
	13	4.05
5/16"	99	19.42
	75	16.78
	50	13.66
	23	9.22
	13	6.94
3/8"	95	27.76
	75	24.90
	50	19.93
	23.	13.50
	13	10.02

Data furnished by Underwriters' Laboratories, showing total discharge from the heads used, at various service pressures.

SAMPLE CALCULATIONS.

SHEET NO. 1-A;

Gauge Pressure -------- 15# / sq. in.

Calibration Correction- 1.1#/sq.in.

True Gauge Pressure -- 13.9#/sq.in.

Velocity Factor Correction:

$$h = \frac{V^2}{2g} \qquad V = \frac{q}{a} \qquad a = .7854\ d^2$$

d (the diameter of the piezometer tube) = .755 in.

$$h = \frac{q^2}{(.7854)^2 \times 64.32 \times d^4} \quad \text{(in feet water)}$$

Changing to pressure in #/sq.in., the result-equation is:

$$Pv = \frac{(.1337)^2 \times 12^4 \times .434}{(.7854)^2 \times 64.32 \times 60^2} \times \frac{q^2}{d4} = K\ \frac{q^2}{d^4}$$

Solving:

$$K = .0011263$$

$$Pv = .0011263\ \frac{q^2}{d^4}$$

d = .755 by actual measurement

$$\text{then } K' = \frac{.0011263}{(.755)^4} = .003466$$

and $Pv = .003466 \times q^2$

Where, P V = pressure correction in #/sq.in.

q = discharge in G.P.M.

d = diameter of piezometer.

From velocity factor correction curve:

Discharge = 9.4 G.P.M.

Correction = 0.3#/sq.in.

True gauge pressure = 13.9#/sq.in.

Effective pressure = 14.2#/sq.in.

Calculation for pan #8, same run:

Weight of water = 21.89#

Time of run = 3 min.

No.of lbs. in 1 gal. = 8.36

Gallons per min. $= \left(\frac{21.89}{3 \times 8.36}\right)$

$= .875$

Total gallons per minute thrown on roof

= sum of G.P.M. in pans 1 to 16 inclusive

= 5.067

Assuming half of total discharge is thrown on roof:

total discharge = 10.134.

DATA
RIDGE POLE SPRINKLER DISTRIBUTION

Position of Head:- Arms Vertical and Perpendicular to Ridge Pole. Sheet No. 1-A.

Diameter of Sprinkler Orifice: 3/8 inch. Date 3-4-18.

Gage Pressure.	Observed.	15.0		25.0		50.0		75.0		100.0	
	True.	13.9		23.7		51.0		77.0		103.0	
Velocity Factor.		.3		.62		1.63		2.20		2.82	
Total Pressure.		14.2		24.32		52.63		79.2		105.82	
Time of Run. (Min.)		3		4		3		2.5		1.5	
		Weight	G.P.M.	Weight.	G.P.M.	Weight.	G.P.M.	Weight.	G.P.M.	Weight.	G.P.M
PANS.	1	.30	.012	1.41	.042	1.04	.041	.60	.029	.10	.008
	2	2.18	.087	4.81	.144	4.36	.174	3.94	.188	1.10	.091
	3	2.26	.090	5.92	.177	5.81	.232	5.67	.271	2.64	.218
	4	3.28	.131	5.31	.159	4.76	.190	4.19	.200	5.70	.471
	5	6.92	.251	12.64	.378	17.95	.715	22.64	1.082	13.95	1.150
	6	9.55	.382	22.21	.661	28.90	1.150	31.40	1.500	21.40	1.770
	7	11.80	.473	18.76	.560	19.64	.783	19.45	.930	13.73	1.135
	8	21.89	.875	33.63	1.000	32.33	1.290	32.00	1.530	20.69	1.710
	9	29.56	1.180	41.75	1.250	40.62	1.620	40.12	1.920	29.16	2.410
	10	14.01	.560	23.62	.706	25.35	1.010	24.25	1.160	16.95	1.400
	11	11.93	.477	19.56	.585	22.56	.900	22.87	1.090	16.56	1.370
	12	6.12	.245	11.81	.354	13.83	.551	16.56	.793	13.18	1.090
	13	4.38	.175	7.85	.234	12.85	.512	15.24	.730	11.44	.945
	14	3.53	.141	5.38	.160	7.22	.288	7.91	.378	5.18	.428
	15	3.30	.132	6.09	.182	6.65	.265	6.60	.316	2.53	.209
	16	1.40	.056	3.72	.111	2.72	.108	1.62	.077	.46	.038
Totals			5.067		6.708		9.80		12.195		14.463
Total Discharge			9.4		12.90		19.9		25.15		28.2

DATA

RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Inclined 15° back. Arms Perpendicular to Ridge Pole. Sheet No. 1-B

Diameter of Sprinkler Orifice- 3/8 inches. Date 3-7-18

Gage Pressure.	Observed.		15.0		100.0
	True.		13.7		103.0
Velocity Factor.			.67		2.82
Total Pressure.			14.37		105.82
Time of Run. (Min.)		4		2	
		Weight	G.P.M.	Weight	G.P.M.
	1	.52	.018	.40	.023
	2	4.21	.126	2.78	.166
	3	4.24	.127	5.43	.324
	4	4.56	.136	10.31	.616
	5	9.89	.295	17.83	1.060
	6	13.21	.395	27.40	1.630
	7	12.14	.363	17.83	1.060
Pans-	8	23.64	.707	26.44	1.580
	9	32.81	.983	34.78	2.080
	10	17.44	.522	21.33	1.273
	11	12.97	.388	19.96	1.192
	12	8.13	.243	16.31	.975
	13	7.26	.217	17.79	1.060
	14	4.78	.143	10.24	.612
	15	6.05	.181	6.36	.380
	16	3.59	.107	1.31	.078
Totals			4.95		14.11
Total Discharge			9.5		28.2

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Incline 15° front. Arms Perpendicular to Ridge Pole. Sheet No. 1-C

Diameter of Sprinkler Orifice:- 3/8 inches. 3-7-18

Gage Pressure.	Observed.	15.0	100.0
	True.	13.8	101.0
Velocity Factor.		.3	2.77
Total Pressure.		14.1	103.77
Time of Run. (Min.)		6	2

		Weight	G.P.M.	Weight	G.P.M.
	1	.10	.002	.17	.010
	2	1.25	.025	1.25	.075
	3	2.43	.048	2.20	.131
	4	3.50	.070	2.70	.161
Pans -	5	10.07	.201	21.39	1.280
	6	21.27	.425	32.65	1.950
	7	30.54	.609	18.07	1.080
	8	35.82	.714	26.56	1.585
	9	48.93	.986	37.50	2.240
	10	27.50	.548	22.38	1.340
	11	19.06	.380	25.44	1.520
	12	9.37	.187	18.87	1.130
	13	5.79	.115	10.26	.612
	14	2.34	.047	3.53	.211
	15	2.29	.046	1.71	.102
	16	.43	.008	.19	.011
Total-			4.41		13.44
Total Discharge			9.4		28.0

DATA

RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Parallel to Ridge Pole. Sheet No. 1D

Diameter of Sprinkler Orifice:- 3/8 inches. Date 3-27-18

Gage Pressure.	Observed.	15.0		25.0		50.0		75.0		100.0	
	True.	13.8		23.7		50.0		75.0		101.0	
Velocity Factor.		.3		.62		1.3		2.1		2.77	
Total Pressure.		14.1		24.32		51.3		77.1		103.77	
Time of Run (Min.)		4		4		3		2		2	
		Weight.	G.P.M.	Weight.	G.P.M.	Weight	G.P.M.	Weight	G.P.M.,	Weight	G.P.M.
Pans-	1	.32	.010	.90	.027	.79	.031	.28	.018	.23	.017
	2	2.19	.065	3.63	.108	3.19	.127	1.31	.078	1.00	.060
	3	3.17	.095	4.55	.136	3.24	.129	1.68	.100	2.05	.120
	4	3.50	.104	5.00	.140	5.81	.232	3.63	.217	2.37	.141
	5	10.20	.305	14.51	.434	14.70	.585	21.80	1.305	16.57	.990
	6	17.09	.511	24.34	.727	32.40	1.290	30.40	1.819	43.34	2.590
	7	17.76	.531	24.14	.722	27.64	1.100	20.70	1.238	22.14	1.320
	8	27.56	.825	34.44	1.030	32.31	1.290	24.69	1.478	28.25	1.690
	9	36.87	1.100	44.80	1.340	42.06	1.675	32.50	1.943	38.06	2.270
	10	24.06	.720	36.44	1.090	40.50	1.615	32.43	1.940	35.06	2.090
	11	12.81	.383	20.59	.616	27,69	1.100	24.06	1.440	30.87	1.845
	12	5.87	.176	8.56	.256	10.24	.408	9.06	.542	9.72	.582
	13	4.53	.135	5.65	.169	4.04	.161	3.29	.197	2.66	.159
	14	2.29	.068	3.53	.106	3.73	.149	1.78	.106	1.28	.076
	15	2.00	.059	3.29	.098	2.34	.093	.90	.054	.40	.024
	16	.56	.017	1.56	.047	.81	.032	.19	.001	.14	.008
Total-			5.10		8.21		10.02		12.49		13.93
Total Discharge			9.4		12.9		19.6		24.8		28.0

DATA.
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Perpendicular to Ridge Pole. Sheet No. 1-E.

Diameter of Sprinkler Orifice:- 3/8 inch. Date 3-20-18

Gage Pressure.	Observed.	15.0	100.0
	True.	13.7	98.0
Velocity Pressure.		.3	2.8
Total Pressure.		14.0	100.8
Time of Run. (Min.)			

		Weight.	G.P.M.	Weight	G.P. M.
PANS.	1	0.67	.0161	.11	.0061
	2	3.81	.0915	1.94	.1075
	3	4.86	.1165	4.99	.276
	4	5.50	.1315	9.75	.539
	5	12.26	.301	18.89	1.024
	6	18.84	.452	30.40	1.680
	7	18.01	.431	18.70	1.035
	8	41.56	.995	33.13	1.841
	9	39.75	.950	36.62	2.03
	10	23.81	.569	27.50	1.525
	11	15.13	.361	21.00	1.165
	12	9.00	.216	19.12	1.055
	13	7.16	.171	11.97	.660
	14	7.09	.169	7.47	.411
	15	3.65	.0875	3.77	.209
	16	2.81	.0675	.93	0.0506
Totals			5.125		13.614
Total Discharge			9.4		27.80

NOTE:- 3 ft. pipe extending beyond head.

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Perpendicular to Ridge Pole. Sheet No. 2-A.

Diameter of Sprinkler Orifice: 1/4 inch. Date 3-4-18

Gage Pressure.	Observed.	15.0		25.0		50.0		75.0		100.0	
	True.	13.9		23.7		51.0		75.0		103.0	
Velocity Factor.		.1		.15		.59		.4		.5	
Total Pressure.		14.0		23.85		51.59		75.4		103.5	
Time of Run (Min.)		5		5		5		5		3	
		Weight.	G.P.M.	Weight.	G.P.M.	Weight.	G.P.M.	Weight.	G.P.M.	Weight.	G.P.M.
	1	.10	.002	1.91	.046	1.04	.025	.79	.019	.24	.009
	2.	1.30	.031	1.77	.042	3.19	.076	3.60	.086	1.70	.068
	3	1.55	.037	2.05	.049	3.67	.087	4.11	.098	3.95	.158
	4	2.37	.057	2.25	.053	3.06	.073	4.84	.116	2.25	.090
	5	5.20	.125	6.51	.156	11.17	.267	15.45	.370	12.42	.497
	6	5.55	.134	10.21	.244	17.84	.426	24.40	.583	15.80	.633
	7	7.95	.191	8.76	.210	13.26	.217	17.47	.418	13.26	.530
PANS.	8	22.56	.541	23.56	.562	29.53	.706	33.21	.795	22.19	.885
	9	26.43	.636	29.57	.706	38.25	.916	45.59	1.090	32.31	1.129
	10	6.75	.161	9.44	.226	16.00	.382	21.94	.525	16.69	.667
	11	6.56	.158	6.87	.165	11.13	.270	14.94	.358	10.00	.400
	12	2.71	.065	3.22	.077	4.25	.102	8.62	.206	6.25	.250
	13	2.34	.056	3.44	.082	4.10	.098	6.29	.150	4.78	.191
	14	1.84	.044	1.34	.032	4.03	.096	2.62	.062	2.03	.081
	15	2.96	.070	2.65	.063	1.34	.032	4.53	1.108	2.90	.116
	16	1.56	.037	2.87	.068	3.96	.095	3.81	.090	1.78	.071
Totals			2.395		2.782		3.968		4.887		5.847
Total Discharge			3.8		5.44		8.05		9.95		11.20

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms 15° Back and Perpendicular to Ridge Pole.

Sheet No. 2-B.

Diameter of Sprinkler Orifice:- -1/4 inch.

Date 3-5-18

Tested by Mann
Marx
Evans.

Gage Pressure.	Observed.		15.0		100.0
	True.		13.7		103.0
Velocity Factor.			.1		.5
Total Pressure.			13.8		103.5
Time of Run. (Min.)			6		4
		Weight	G.P.M.	Weight.	G.P.M.
	1	1.24	.024	2.20	.058
	2	2.55	.050	5.66	.150
	3	3.00	.509	5.46	.145
	4	3.37	.067	6.50	.172
	5	6.20	.123	18.75	.498
	6	7.65	.152	22.60	.600
	7	7.40	.147	18.50	.492
PANS.	8	23.31	.464	30.74	.818
	9	26.00	.518	43.81	1.160
	10	7.06	.141	22.53	.598
	11	6.77	.135	17.40	.462
	12	3.31	.066	10.69	.284
	13	3.28	.065	8.97	.238
	14	1.53	.030	5.40	.143
	15	3.02	.060	3.86	.103
	16	4.73	.094	4.76	.126
Totals			2.179		6.109
Total Discharge			3.8		11.30

DATA

RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Inclined 15° front. Arms Perpendicular to Ridge Pole. Sheet No. 2-C

Diameter of Sprinkler Orifice: 1/4 inch. Date 3-7-18

Gage Pressure.	Observed.	15.0	100.0
	True.	13.7	103.0
Velocity Factor.		.1	.5
Total Pressure.		13.8	103.5
Time of Run. (Min.)		6	4

		Weight	G.P.M.	Weight	G.P.M.
PANS.	1	.00	.000	.00	.000
	2	.00	.000	.94	.028
	3	.00	.000	1.55	.046
	4	6.06	.012	3.10	.090
	5	5.20	.104	13.70	.410
	6	9.77	.195	26.77	.802
	7	9.89	.197	17.54	.525
	8	25.53	.509	27.06	.809
	9	31.96	.638	38.69	1.160
	10	10.62	.212	23.06	.690
	11	7.11	.142	14.44	.432
	12	4.78	.009	9.87	.295
	13	1.14	.002	4.88	.146
	14	.00	.000	1.72	.051
	15	.00	.000	.79	.023
	16	.00	.000	.00	.000
Totals			2.02		5.51
Total Discharge			3.8		11.2

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Parallel to Ridge Pole.

Elevation of Deflector above Ridge Pole:- 4-3/4 inches.

Diameter of Sprinkler Orifice: 1/4 inches.

Sheet No. 2-D.

Pitch of Roof- 1:4

Date 3-27-18

Tested by S.L.Evans
R.N.Mann,
F. E. Marx.

Gage Pressure.	Observed.	15.0	25.0	50.0	75.0	100.0
	True.	13.8	23.7	50.0	75.0	101.0
Velocity Factor.		.10	.15	.6	.4	.5
Total Pressure.		13.9	23.85	50.6	75.4	101.5
Time of Run. (Min.)		8	5	4	4	3

		Weight	G.P.M.	Weight	G.P.M.	Weight	G.P.M.	Weight	G.P.M.	Weight	G.P.M.
	1	.60	.009	.81	.019	1.16	.035	.85	.025	.29	.012
	2	2.06	.031	1.50	.036	2.25	.067	2.25	.067	1.50	.060
	3	2.99	.045	2.30	.055	2.68	.080	3.30	.099	2.43	.097
	4	2.69	.040	3.00	.072	3.25	.097	2.88	.086	2.10	.084
	5	7.76	.116	6.64	.159	7.95	.238	10.70	.320	7.83	.312
	6	10.77	.161	9.34	.233	12.49	.374	16.22	.486	17.21	.686
	7	8.76	.131	8.65	.207	12.33	.369	15.95	.477	15.45	.616
Pans-	8	33.03	.495	26.87	.643	28.19	.845	32.69	.979	26.69	1.065
	9	41.75	.625	33.25	.796	33.74	1.010	33.74	1.130	32.31	1.295
	10	14.31	.214	15.88	.380	19.13	.573	24.84	.743	20.31	.810
	11	8.19	.122	7.88	.189	10.03	.300	13.90	.416	13.31	.531
	12	4.69	.070	3.74	.089	4.19	.125	5.81	.174	5.69	.233
	13	4.85	.072	3.16	.076	3.06	.091	3.09	.092	3.65	.145
	14	2.55	.381	2.16	.052	2.28	.068	2.55	.076	2.24	.089
	15	2.59	.039	2.27	.054	2.34	.070	1.71	.051	1.29	.051
	16	2.90	.043	2.94	.070	3.56	.107	1.87	.056	.40	.016
Totals -			2.06		3.12		4.45		5.27		6.09
Total Discharge.			4.05		5.44		8.10		9.95		11.38

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Perpendicular to Ridge Pole. Sheet No. 3-A.

Diameter of Sprinkler Orifice: 5/16 inch. Date 3-12-18

Gage Pressure.	Observed.	15.0	25.0	50.0	75.0	100.0
	True.	13.8	23.8	48.0	75.0	101.0
Velocity Factor.		.25	.22	.6	.95	1.2
Total Pressure.		14.05	24.12	48.6	75.95	102.2
Time of Run. (Min.)		4	4	3	3	2

		Weight	G.P.M.	Weight	G.P.M.	Weight.	G.P.M.	Weight	G.P.M.	Weight	G.P.M.
PANS.	1	.10	.003	.51	.015	.79	.031	1.4	.055	.44	.026
	2	2.00	.060	2.13	.064	2.69	.107	3.37	.134	1.37	.082
	3	3.36	.100	3.86	.115	3.86	.154	5.67	.226	2.55	.152
	4	2.94	.088	3.06	.091	3.00	.119	4.94	.197	3.13	.187
	5	9.37	.281	10.14	.304	12.82	.512	18.64	.744	16.00	.958
	6	14.77	.442	16.90	.506	20.50	.817	27.15	1.08	20.39	1.22
	7	13.39	.401	14.01	.419	13.63	.544	16.33	.651	12.39	.742
	8	30.82	.922	28.25	.845	25.53	1.018	28.88	1.15	22.32	1.335
	9	37.00	1.110	34.65	1.04	34.25	1.365	36.81	1.468	28.56	1.71
	10	14.00	.419	15.81	.473	18.75	.747	20.88	.834	17.22	1.03
	11	8.44	.252	10.00	.299	12.81	.511	15.50	.618	12.65	.757
	12	4.75	.142	4.28	.128	7.75	.301	10.06	.423	7.56	.453
	13	4.41	.133	4.18	.125	4.38	.174	8.97	.357	8.20	.491
	14	3.78	.113	2.78	.083	3.03	.121	4.41	.176	4.15	.248
	15	3.94	.118	4.03	.120	2.90	.155	4.27	.170	2.59	.155
	16	2.37	.070	3.93	.117	3.74	.149	2.50	.099	.81	.048
Totals			4.65		4.745		6.827		8.392		9.595
Total Discharge			7.3		8.9		12.8		16.5		18.8

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Parallel to Ridge Pole. Sheet No. 3-D.

Diameter of Sprinkler Orifice:- 5/16 inches. Date 3-27-18.

Gage Pressure.	Observed.	15.0	25.0	50.0	75.0	100.0
	True.	13.7	23.7	50.0	75.0	100.0
Velocity Factor.		.25	.32	.62	.95	1.20
Total Pressure.		13.95	24.02	50.62	75.95	101.2
Time of Run. (Min.)		6	5	3	3	2

		Weight.	G.P.M.	Weight	G.P.M.	Weight	G.P.M.	Weight	G.P.M.	Weight	G.P.M.
Pans-	1	.00	.00	.66	.004	.29	.012	.29	.012.	.23	.014
	2	.50	.001	1.87	.045	1.36	.050	1.25	.050	.44	.026
	3	.49	.010	2.74	.066	1.56	.062	1.43	.057	.99	.059
	4	3.25	.065	4.81	.115	2.63	.105	3.44	.137	1.63	.097
	5	7.95	.159	11.01	.263	7.45	.297	9.26	.369	6.58	.393
	6	13.90	.277	15.59	.373	14.84	.592	21.27	.848	17.90	1.050
	7	16.39	.327	18.26	.437	16.08	.641	20.98	.837	16.70	1.000
	8	38.06	.760	36.26	.868	28.32	1.130	31.96	1.270	25.58	1.530
	9	45.93	.917	45.00	1.080	33.56	1.340	38.06	1.520	28.56	1.710
	10	25.75	.501	31.38	.751	27.56	1.100	34.62	1.380	27.00	1.620
	11	13.25	.264	16.81	.402	17.25	.688	22.63	.903	19.00	1.140
	12	5.81	.116	6.31	.151	6.50	.259	9.19	.366	7.75	.463
	13	3.79	.076	4.47	.107	2.91	.116	3.06	.122	2.60	.155
	14	3.97	.079	3.47	.083	2.72	.110	3.41	.136	1.78	.106
	15	3.77	.075	3.65	.087	2.27	.090	1.96	.078	1.46	.087
	16	1.06	.021	2.69	.064	1.31	.052	.87	.035	.41	.024
Totals			3.65		4.90		6.65		8.22		9.47
Total Discharge-			7.3		8.9		13.2		16.5		18.8

DATA
RIDGE POLE SPRINKLER DISTRIBUTION.

Position of Head:- Arms Vertical and Perpendicular to Ridge.Pole.

Sheet No. 4-A

Diameter of Sprinkler Orifice: 1/2 inch.

Date 3-16-18.

Gage Pressure.	Observed.	15.0	100.0
	True.	13.8	101.0
Velocity Factor.		1.05	7.35
Total Pressure.		14.85	108.35
Time of Run. (Min.)		4	2

		Weight.	G.P.M.	Weight	G.P.M.
Pans-	1	16.10	.482	19.47	1.165
	2	14.63	.437	19.63	1.173
	3	14.13	.422	17.74	1.061
	4	10.06	.301	16.49	.987
	5	19.25	.576	19.95	1.193
	6	23.40	.700	37.03	2.220
	7	15.70	.470	20.14	1.207
	8	31.25	.935	30.68	1.838
	9	44.06	1.320	41.90	2.510
	10	26.81	.802	33.50	2.005
	11	22.63	.677	31.25	1.870
	12	14.19	.424	24.06	1.440
	13	13.79	.412	25.97	1.550
	14	9.15	.274	20.47	1.225
	15	9.65	.288	15.15	.907
	16	8.14	.243	9.62	.575
Totals			8.76		22.93
Total Discharge			46.00		17.5

TEST TO DETERMINE ABILITY OF HEAD TO WET DOWN 8 FT. SECTION OF ROOF UNAIDED.

Position of Head:

Sheet No. 0.

Vertical.

Arms 90° to Ridge.

Diameter Sprinkler Orifice: 3/8 inch.

Height of Deflector 4$\frac{3}{4}$ in.

Pitch of roof: 1:4

15 lbs.

At end of 1 Min.	Roof thoroughly wet 2 ft. each side of center line.
" " " 2 "	Increased to 2-1/2 ft. each side of center line.
" " " 3 "	Width of 2-1/2 ft. not materially increased.

50 lbs.

At end of 1 Min.	Roof thoroughly wet down 2 ft. each side of center line.
" " " 2 "	Roof thoroughly wet down 2-1/2 ft. each side of center line.
" " " 3 "	Center section entirely wet down.

100 lbs.

Roof entirely wet down in 2 minutes.

NOTES ON DISTRIBUTION.

Position of Head:
Vertical
Arms 90 degrees to Ridge.

Sheet No. 1A

Diameter of Sprinkler Orifice:3/8 inch.

Height of Deflector: 4-3/4".

Pitch of Roof: 1:4

15 lbs.

Heavy drops, spray all falling on roof. Sections 2, 3, 6, 7, evenly covered. Drops thrown 10 feet above head. Estimated thickness in center sections; 1/32 - 1/16 inch.

25 lbs.

Heavy drops, with appreciable amount thrown over edge and both sides. Center sections well covered. Drops thrown 8 feet above head. Estimated depth in center sections: 1/16 inch.

50 lbs.

Large drops, with appreciable amount over edge and sides. Water thrown 8 feet above head. Middle sections well covered., Estimated depth, center sections: 3/32 inch.

75 lbs.

Fine spray, small amount over edge of roof. None over sides. Center sections well

covered. Spray thrown 4 feet above head. Estimated depth, center sections: 3/32 inch.

100 lbs.

Fine spray, all thrown on roof. Thrown 4 feet above head. Middle sections well covered. Estimated depth, center sections: 1/8 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 1B

15° Back.

Arms 90° to Ridge. Diameter Sprinkler Orifice: 3/8 in.

Height of Deflector: 4¾ in. Pitch of Roof: 1:4

15 lbs.

Large drops, appreciable amount thrown over edge; none over deflectors. Middle sections evenly covered. Water thrown 9 feet above head. Distribution not materially different from that with the head, vertical. Estimated thickness, center sections: 1/16 inch.

100 lbs.

Fine spray, some thrown over sides; none over edge. Water thrown 5 feet above head. Sections 2, 3, 6, 7, well covered, and inside of sections 1, 4, 5, 8. No material difference in distribution from head in vertical position. Estimated depth, center sections: 1/8 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 1-C.

15° Front.

Arms 90° to Ridge. Diameter Sprinkler Orifice: 3/8 in.

Height of Deflector: 4-3/4 in. Pitch of Roof: 1:4.

15 lbs.

Large drops, small amount over edge, none over sides. Water thrown 4 feet above head. Middle sections covered 3 feet on each side of center line. Negligible amount in outer sections. Estimated depth, center sections: 1/16 inch.

100 lbs.

Fine spray, all on roof; spray thrown 4 feet above head. Middle sections adequately covered. Estimated depth, center sections: 1/16 - 3/32 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No.1D

Vertical. Diameter Sprinkler Orifice:3/8 inch

Arms Parallel to Ridge.

Height of Deflector: 4-3/4 in. Pitch of Roof:1:4

15 lbs.

Large drops, all thrown on roof. Adequately covered 2 feet each side of center line. Negligible amount on sections 1, 4, 5, 8. Water thrown 8 feet above head. Estimated depth, center sections: 1/16 inch.

25 lbs.

Large drops, all thrown on roof, and practically none thrown above head. Adequately covered about 2-1/2 feet each side of center line. Estimated depth, center sections: 1/16 inch.

50 lbs.

Large drops, all thrown on roof. Middle sections very well covered. Outer sections nearly dry. Negligible amount thrown above head. Estimated depth, center sections: 3/32 in.

75 lbs.

Fine spray, small amount being thrown over edge, none over sides. Middle sections well covered, uneven distribution in outer sections. Spray thrown 8 feet above head. Estimated depth, center sections: 3/32 inch.

100 lbs.

Fine spray, all thrown on roof. Distribution concentrated over middle sections. Negligible amount in sections 1, 4, 5, 8. Water thrown 4 feet above head. Estimated depth, center sections: 1/8 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 1-E

Vertical.

Arms 90° to Ridge. Diameter of sprinkler orifice.3/8 in.

Height of Deflector 4-3/4 in. Pitch of Roof: 1:4

REMARKS: A three foot piece of 3/4 inch pipe is placed in the tee, extending beyond the head.

15 lbs.

Essentially the same distribution as without the pipe extension. These were a few more drops over the West deflector than the East.

100 lbs.

Approximately the same distribution as without pipe extension.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 2-A.

Vertical.

Arms 90° to Ridge. Diameter Sprinkler Orifice: 1/4 in.

Height of Deflector: 4-3/4 in. Pitch of Roof: 1:4

15 lbs.

Heavy drops, some water over edge, none over sides. Very little thrown above head. Center sections covered to 2 feet on each side of roof, center line. Outer sections nearly dry. Estimated depth, center sections: 1/32 - 1/16 inch.

25. lbs.

Large drops, some over edge, none over sides or above head. Roof well covered to 2 feet, each side of center line. Poor distribution in outer sections. Estimated depth, 1/32 - 1/16 inch.

50 lbs.

Large drops, considerable amount over edge, small amount over sides. None above head. Middle sections fairly well wet down. Estimated depth, center sections: 1/16 - 3/32 inch.

75 lbs.

Fine spray, all thrown on roof, and none above head. Good distribution in middle sections; ppor in outer sections. Estimated depth, center sections: 1/16 - 3/32 inch.

100 lbs.

Fine spray, all thrown on roof, and about 1 foot above head. Middle sections adequately covered; poor distribution in outer sections. Estimated depth, center sections: 1/16 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 2-B.

15° Back.

Arms 90° to Ridge. Diameter Sprinkler Orifice: 1/4 in.

Height of Deflector 4-3/4 in. Pitch of Roof: 1:4

15 lbs.

Large drops, small amounts over edge and sides. Negligible amount thrown above head. Middle sections inadequately covered, and outer sections nearly dry. Estimated thickness, center sections: 1/32 - 1/16 inch.

100 lbs.

Fine spray, water thrown over sides and edge, with very little thrown above head. Outer sections very poorly covered, middle sections fairly well covered. Estimated depth, center sections: 1/16 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 2-C.

15° Front.

Arms 90° to Ridge. Diameter Sprinkler Orifice : 1/4 in.

Height of Deflector 4-3/4 in. Pitch of Roof: 1:4

15 lbs.

Large drops, all thrown on roof; very little thrown above head. Sections 1, 4, 5, and 8, nearly dry. Middle sections only covered to about 2 feet, each side of center line. Estimated depth, center sections: 1/32 in.

100 lbs.

Fine spray, all on roof, very little thrown above head. Middle sections well covered, small amount in sections 1, 4, 5, and 8. Estimated depth, center sections: 1/16 - 3/32 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 2-D.

Vertical.

Arms Parallel to Ridge. Diameter Sprinkler Orifice: 1/4 in.

Height of Deflector: 4-3/4 in. Pitch of Roof 1:4

15 lbs.

Large drops, with considerable amount over edge, and none over sides. Roof evenly wet down 2 feet on each side, center line. Poor distribution outside of this area. Negligible amount thrown above head. Estimated depth, center sections: 1/32 inch.

25 lbs.

Large drops, considerable over edge, none over sides, and very small amount thrown above the head. Middle sections not adequately covered. Estimated depth, center sections: 1/32 - 1/16 inch.

50 lbs.

Approximately same condition as at 25 lbs. Estimated thickness, center sections, 1/16 in.

75 lbs.

Large drops, very little over edge. None above head or over sides. Roof well covered 3 feet each side of center line. Small amount of water in outer sections. Estimated depth: 1/16 - 3/32 inch.

100 lbs.

Fine spray, small amount over edge, none over sides or above head. Middle sections fairly well covered. Estimated depth, center sections, 3/32 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 3-A.

Vertical.

Arms 90° to Ridge. Diameter Sprinkler Orifice: 5/16 in.

Height of Deflector 4-3/4 in. Pitch of Roof: 1:4.

15 lbs.

Large drops, small amount over edge, none over deflectors, and very little thrown above head. Roof adequately covered 2 feet on each side of center line. Outer sections nearly dry. Estimated depth, center sections: 1/16 inch.

25 lbs.

Large drops, considerable over edge. None over sides or above head. Center sections covered 3 feet, each side of center line. Small amount of water in outer sections. Estimated depth, center sections: 1/16 inch.

50 lbs.

Large drops, considerable amount over edge and both sides. Water thrown about 4 feet above

head. Middle sections well covered. Poor distribution in outer sections. Estimated depth, center sections: 1/16 - 3/32 inch.

75 lbs.

Fine spray, all thrown on roof, water thrown 2 feet above head. Middle sections and inside of outer sections well covered. Estimated depth, center sections: 1/16 - 3/32 in.

100 lbs.

Fine spray, all thrown on roof. Water thrown 2 feet above head. Middle sections and inside of outer sections well covered. Estimated depth, center sections: 3/32 inch.

NOTES ON DISTRIBUTION.

Position of Head:	Sheet No.3D
Vertical	Diameter Sprinkler Orifice:5/16 in.
Arms Parallel to Ridge.	
Height of Deflector: 4-3/4 in.	Pitch of Roof: 1:4

15 lbs.

Large drops, occasional drops over edge; none over deflectors. Water concentrated on middle sections. Outer sections nearly dry. Negligible amount thrown above head. Estimated depth, center sections, 1/16 inch.

25 lbs.

Large drops, none above head; small amount over edge; none over deflectors. Water concentrated in center sections; negligible amount in outer sections. Estimated depth, center sections; 1/16 inch.

50 lbs.

Large drops, none above head; small amount over edge; none over sides. Middle sections well covered. Very little in outer sections. Estimated depth, center sections, 1/16 inch.

75 lbs.

Large drops, none thrown above head or over deflectors. Small amount over edge. Middle very well covered, outer sections poorly covered. Estimated depth, center section: 1/16 inch.

100 lbs.

Fine spray, none over edge or deflectors. Middle sections well wet down. Inside of outer sections fairly well covered. No water thrown above head. Estimated depth, center sections; 1/16 - 3/32 inch.

NOTES ON DISTRIBUTION.

Position of Head: Sheet No. 4-A.

Vertical.

Arms 90° to Ridge. Diameter Sprinkler Orifice: 1/2 in.

Height of Deflector: 4-3/4 in. Pitch of Roof: 1:4

15 lbs.

Large drops, with large amount over edge and sides. Estimated 60 per cent of water thrown high in air. Middle sections completely covered, and outer sections nearly the same. Estimated thickness, center sections: 1/16 inch.

100 lbs.

Fine spray, large amount over sides and edge. All sections covered about equally. Large amount of water caught by deflector, giving unusually large amount in end pans. Estimated depth, center sections: 3/32 - 1/8 inch.

CURVES AND CHARTS

INDEX TO CURVES AND CHARTS

Pressure- Discharge- Curves

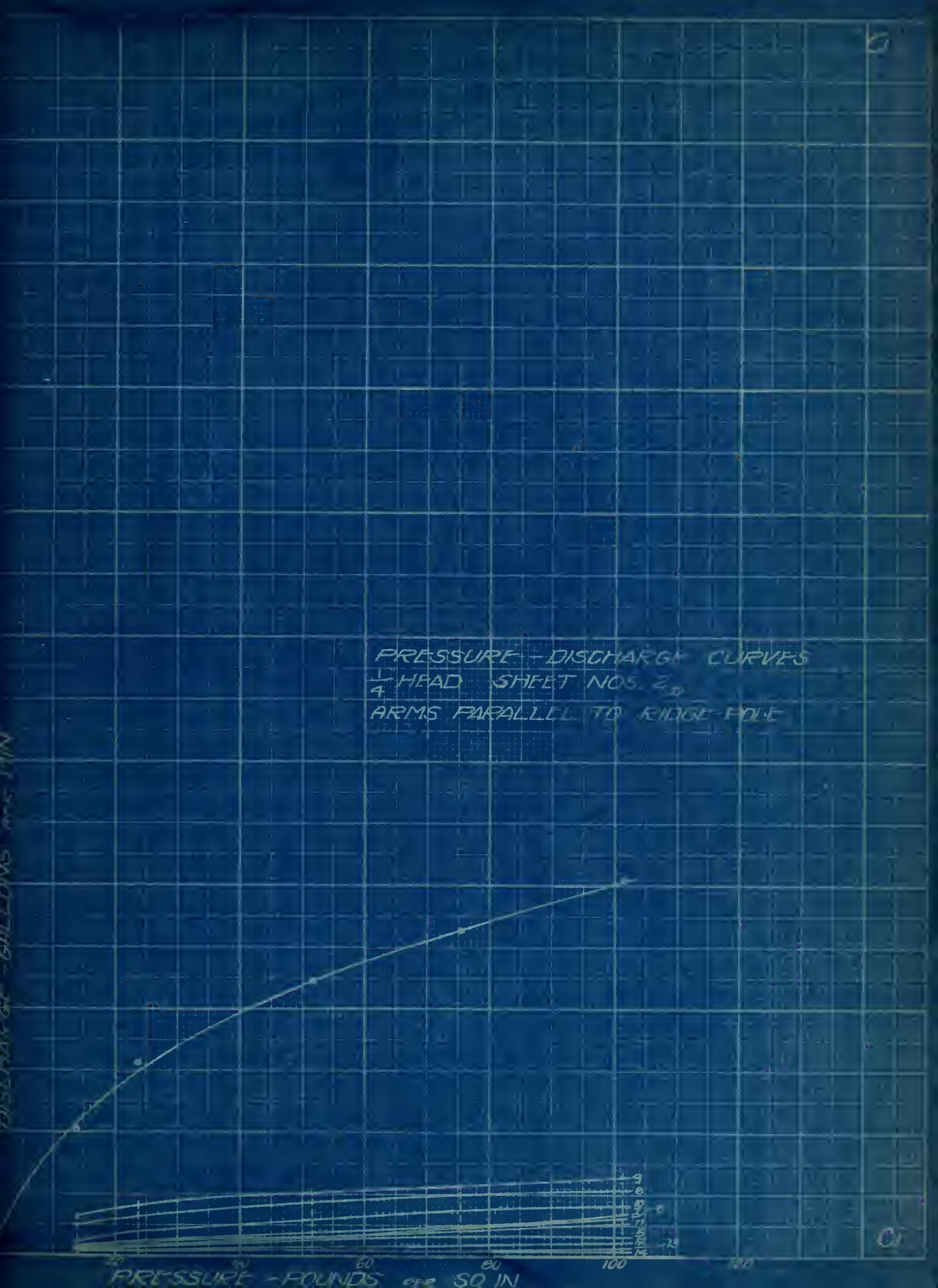
	1/4"	3/16"	3/8"
Head Vertical, Arms Parallel to Ridge-Pole.	C1	C3	C5
" " " Perpendicular to Ridge-Pole	C2	C4	C6
Summary	C7		
Velocity Factor Curve	C8		

Distribution Charts.

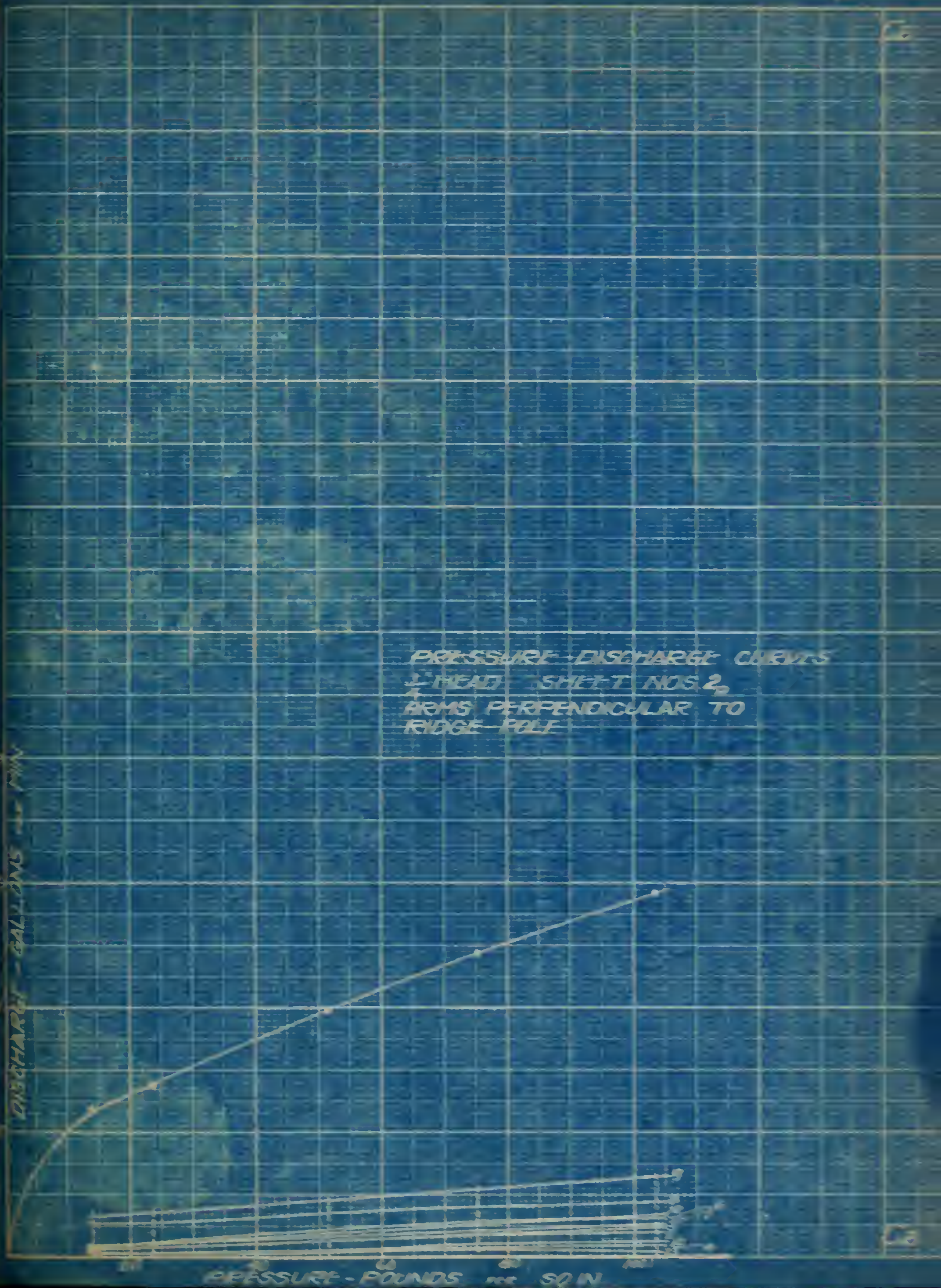
	1/4"	5/16"	3/8"	1/2"
Pressure 15 - 100#, Head Vertical, Arms Parallel to Ridge-Pole	C9	C15	C19	
25 - 50- 75#, " " " " " " "	C10	C16	C20	
15- 100#, " " " Perpendicular to Ridge-Pole	C11	C17	C21	C26
25, 50, - 75#," " " " " " "	C12	C18	C22	
15- 100#, " " " " " " " (with 3 ft. extension beyond head)			C23	
15- 100#, Head Inclined 15° back, Arms Perpendicular to Ridge.	C13		C24	
15- 100#, " " 15° front, " " " "	C14		C25	

Charts for Comparison of Discharges with Head in Different Positions.

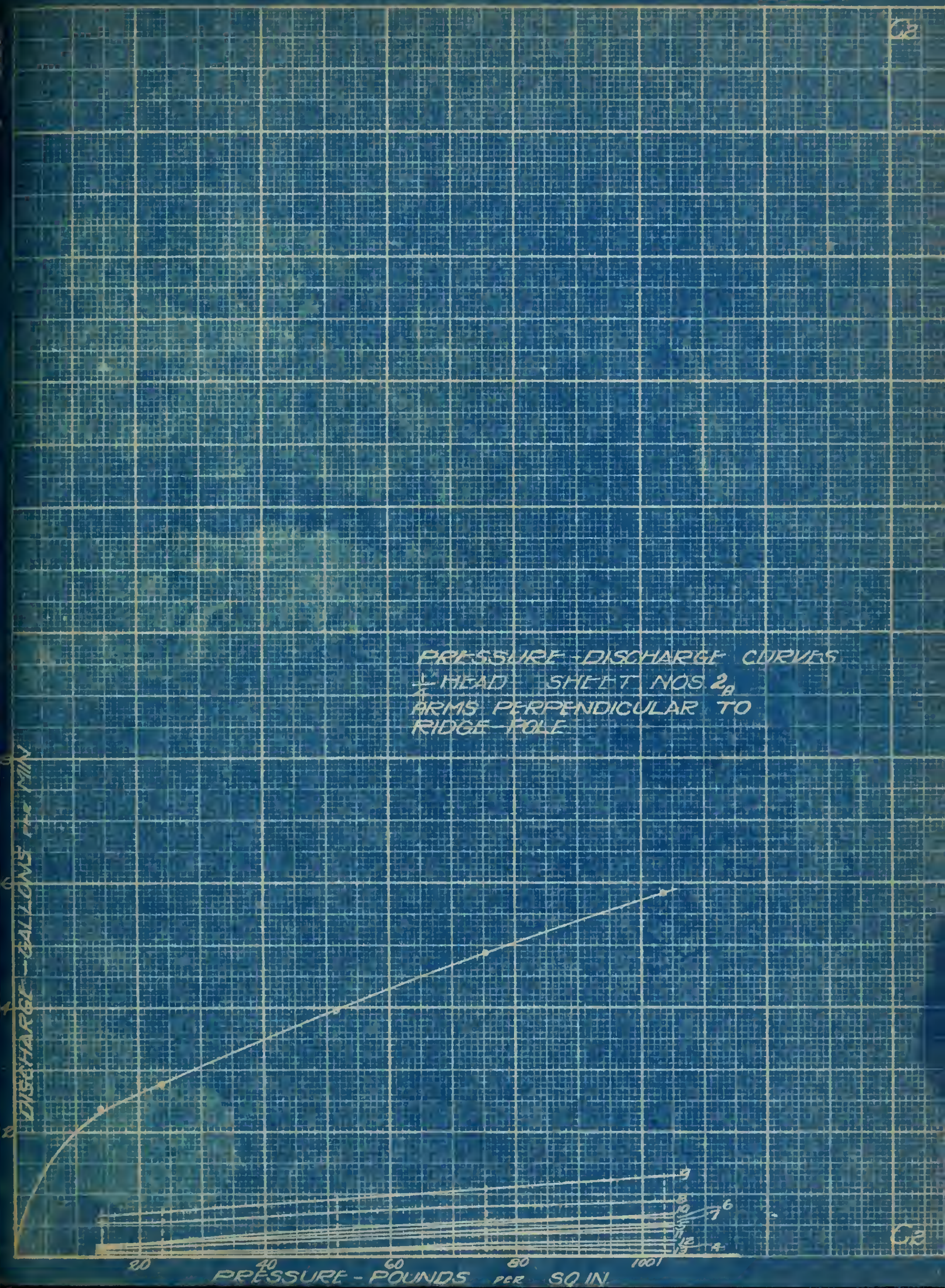
	1/4"	5/16"	3/8"
Pressure 15#; Arms Perpendicular to Ridge; Head Vertical - Head 15° Back -----	C27		C41
" 15#; " " " " " " " 15° Front ----	C28		C42
" 100#; " " " " " " " 15° Back -----	C29		C43
" 100#; " " " " " " " 15° Front ----	C30		C44
" 15#; Head Vertical; Arms Perpendicular - Arms Parallel --------------	C31	C36	C45
" 25#; " " " " " " --------------	C32	C37	C46
" 50#; " " " " " " --------------	C33	C38	C47
" 75#; " " " " " " --------------	C34	C39	C48
" 100#; " " " " " " --------------	C35	C40	C49
" 15#; " " " " with & without 3' extension --			C50
" 100#; " " " " " " " 3' " --			C51



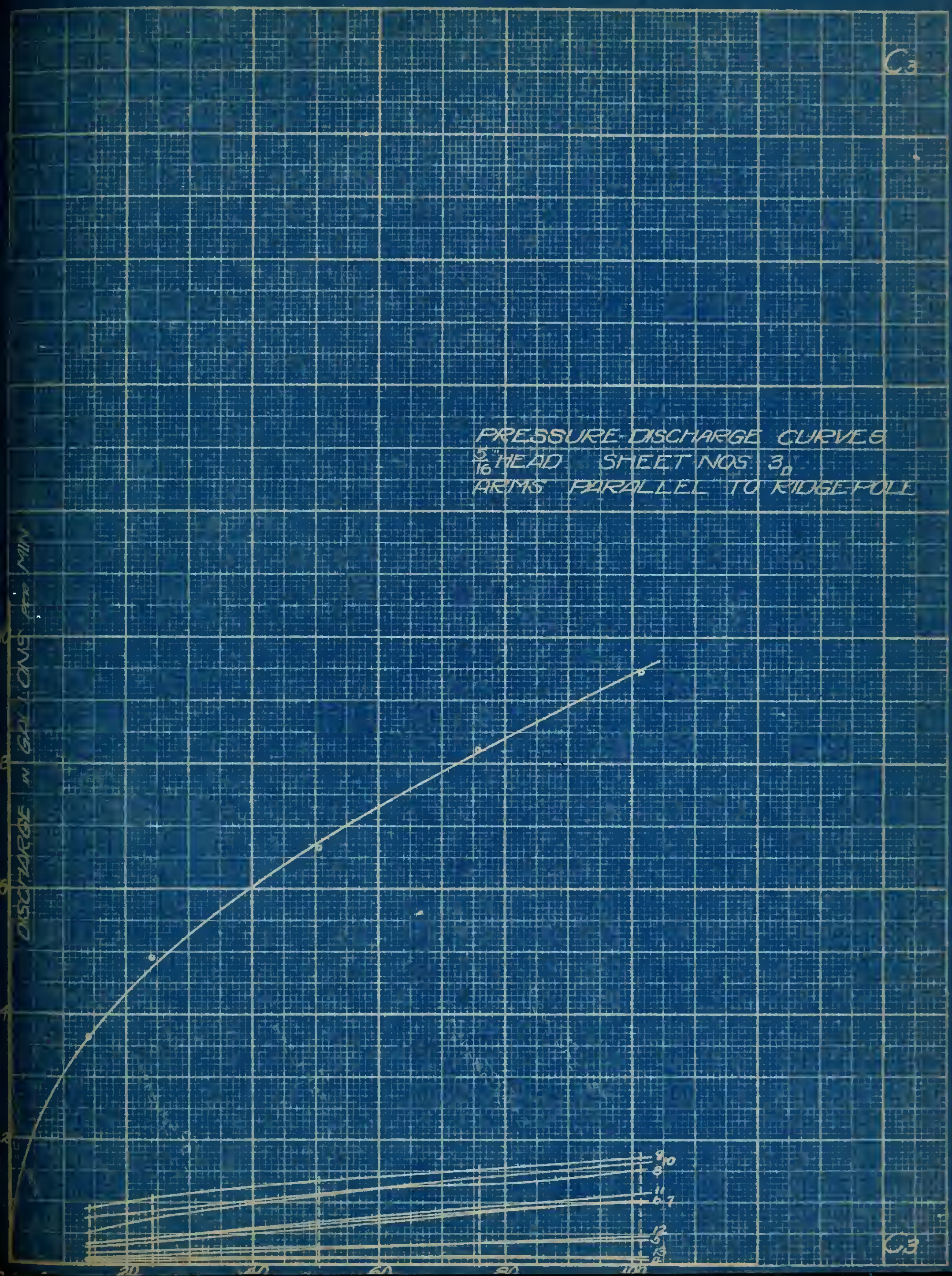
PRESSURE - DISCHARGE CURVES
$\frac{1}{4}$ HEAD SHEET NOS. 2
ARMS PARALLEL TO RIDGE POLE



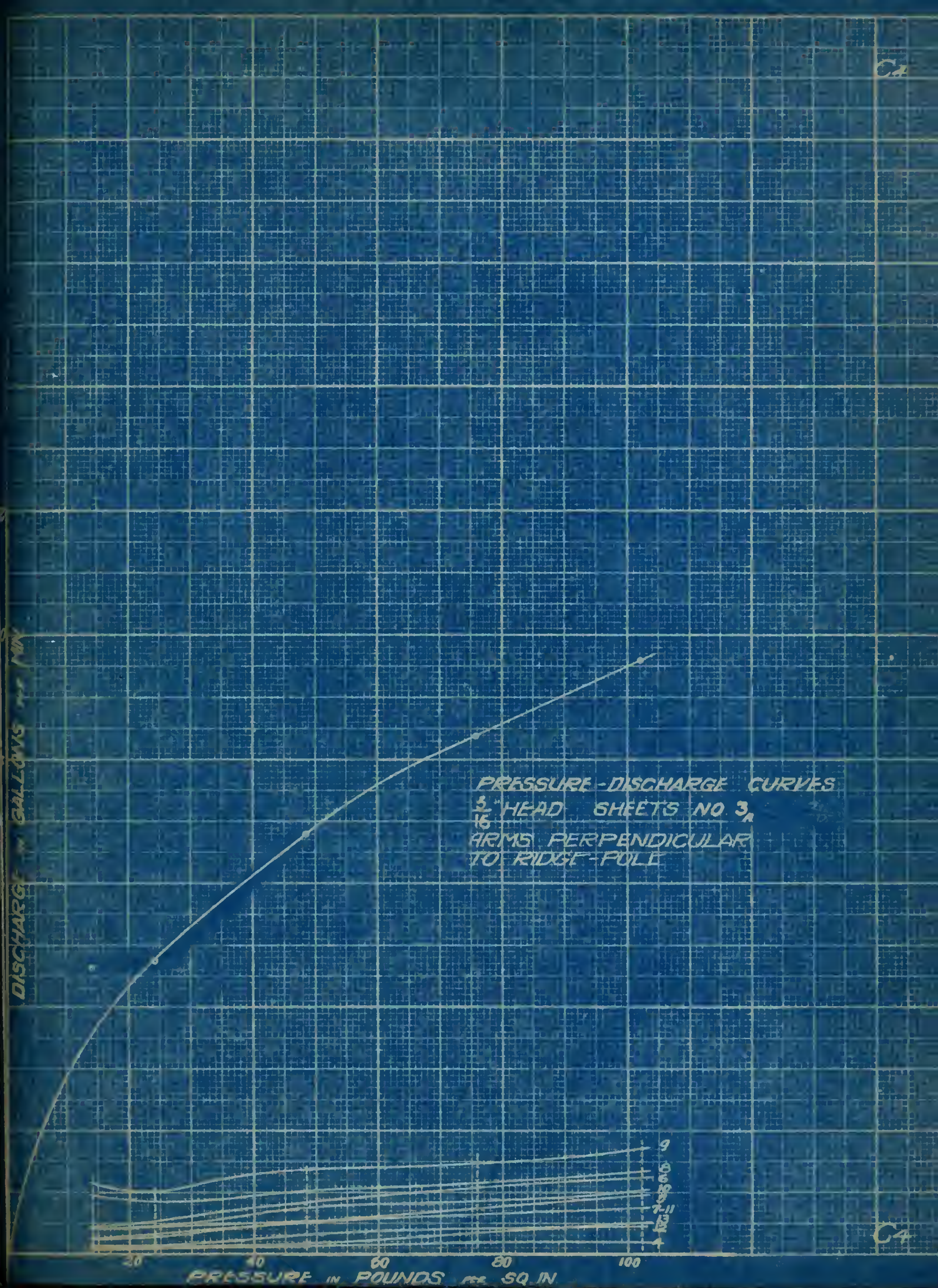
PRESSURE-DISCHARGE CURVES
¼ HEAD SHEET NOS. 2
ARMS PERPENDICULAR TO
RIDGE POLE

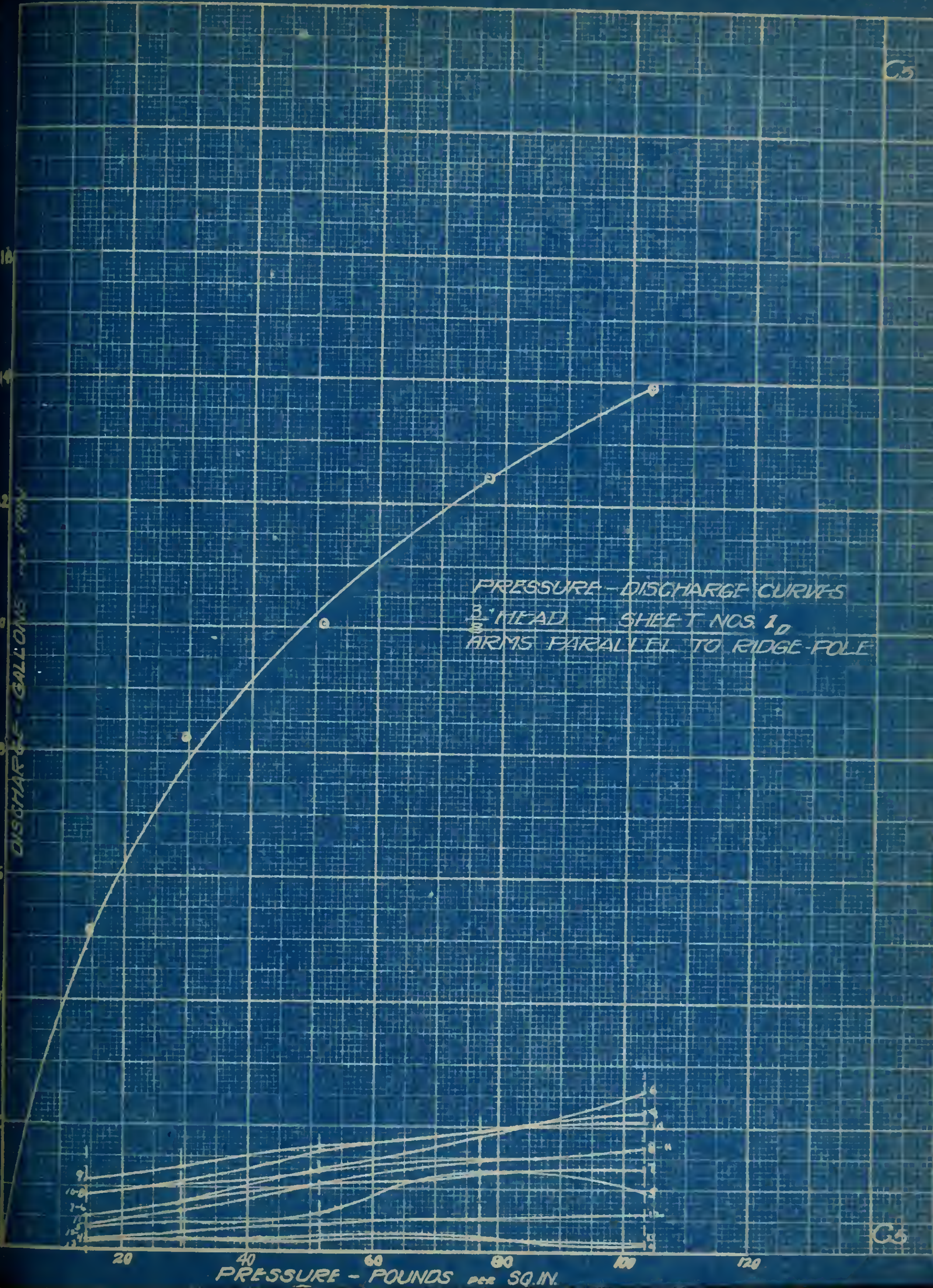


PRESSURE-DISCHARGE CURVES
½ HEAD SHEET NOS. 2_B
ARMS PERPENDICULAR TO
RIDGE POLE

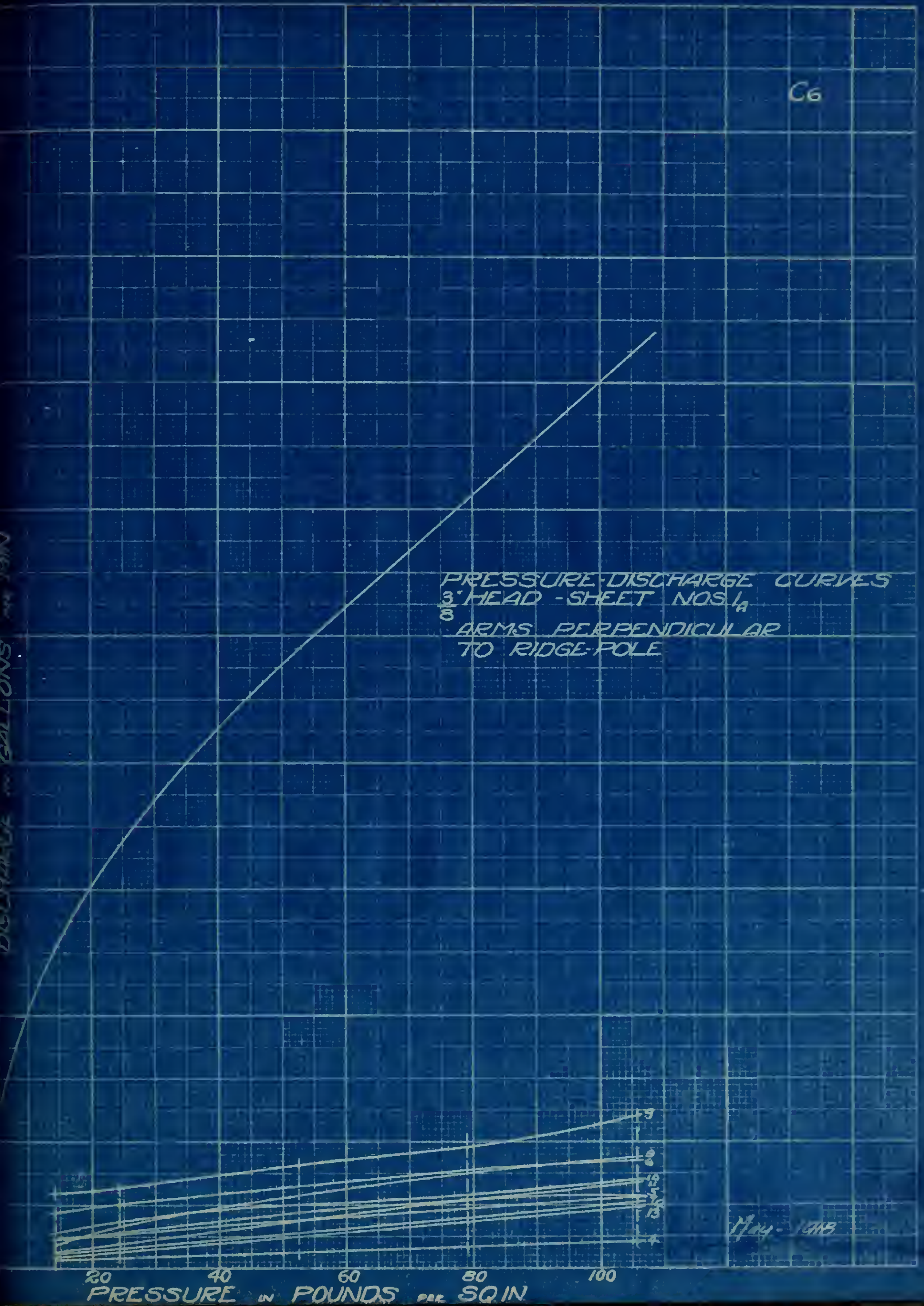


PRESSURE-DISCHARGE CURVES
$\frac{5}{16}$" HEAD SHEET NOS 3_a
ARMS PARALLEL TO RIDGE-POLE



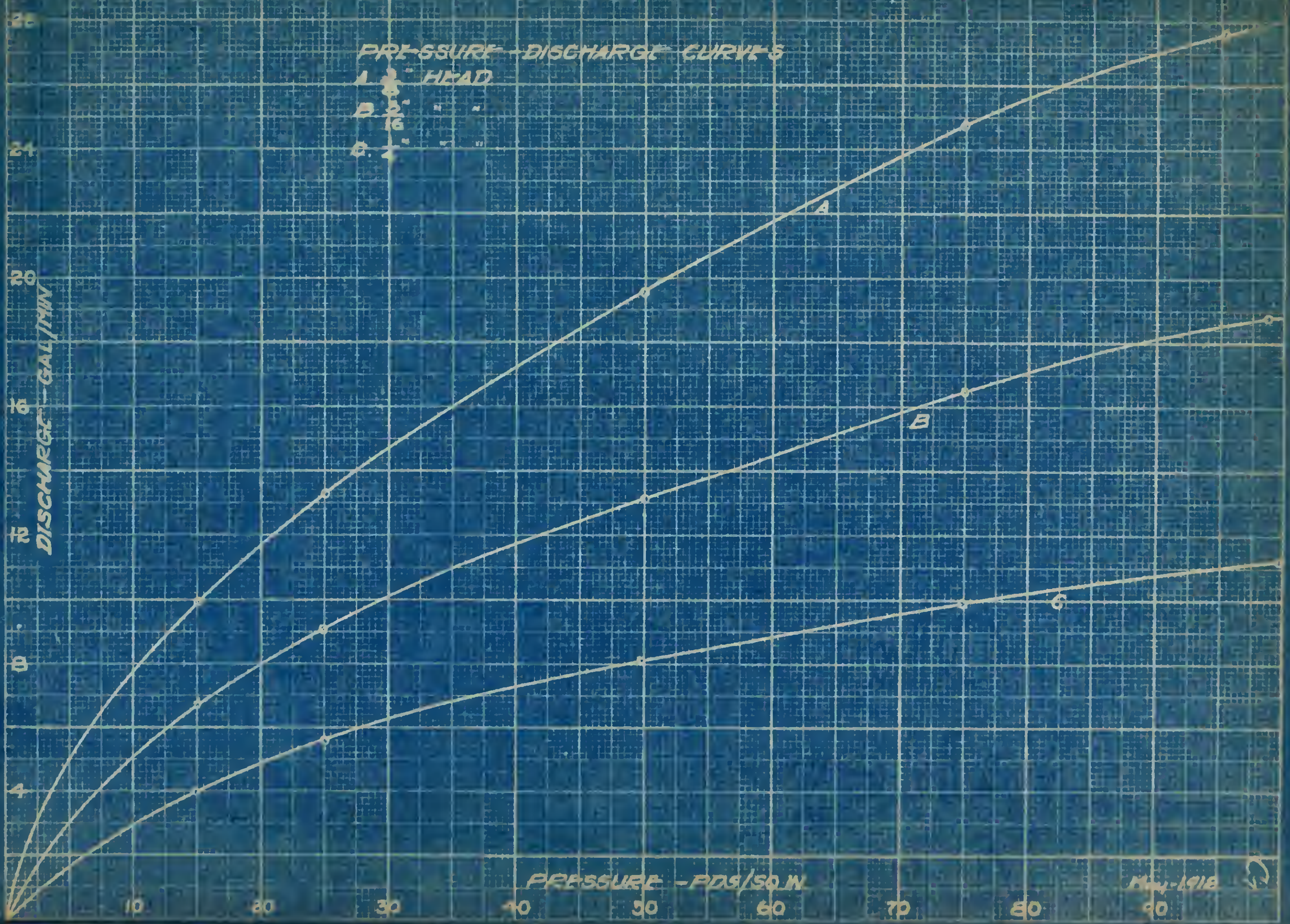

C5
PRESSURE - DISCHARGE CURVES
3/8" HEAD - SHEET NOS. 1D
ARMS PARALLEL TO RIDGE-POLE
DISCHARGE - GALLONS per MIN
16
14
12
10
8
6
4
2
9
10-6
20
40
60
80
100
120
PRESSURE - POUNDS per SQ.IN.
C5

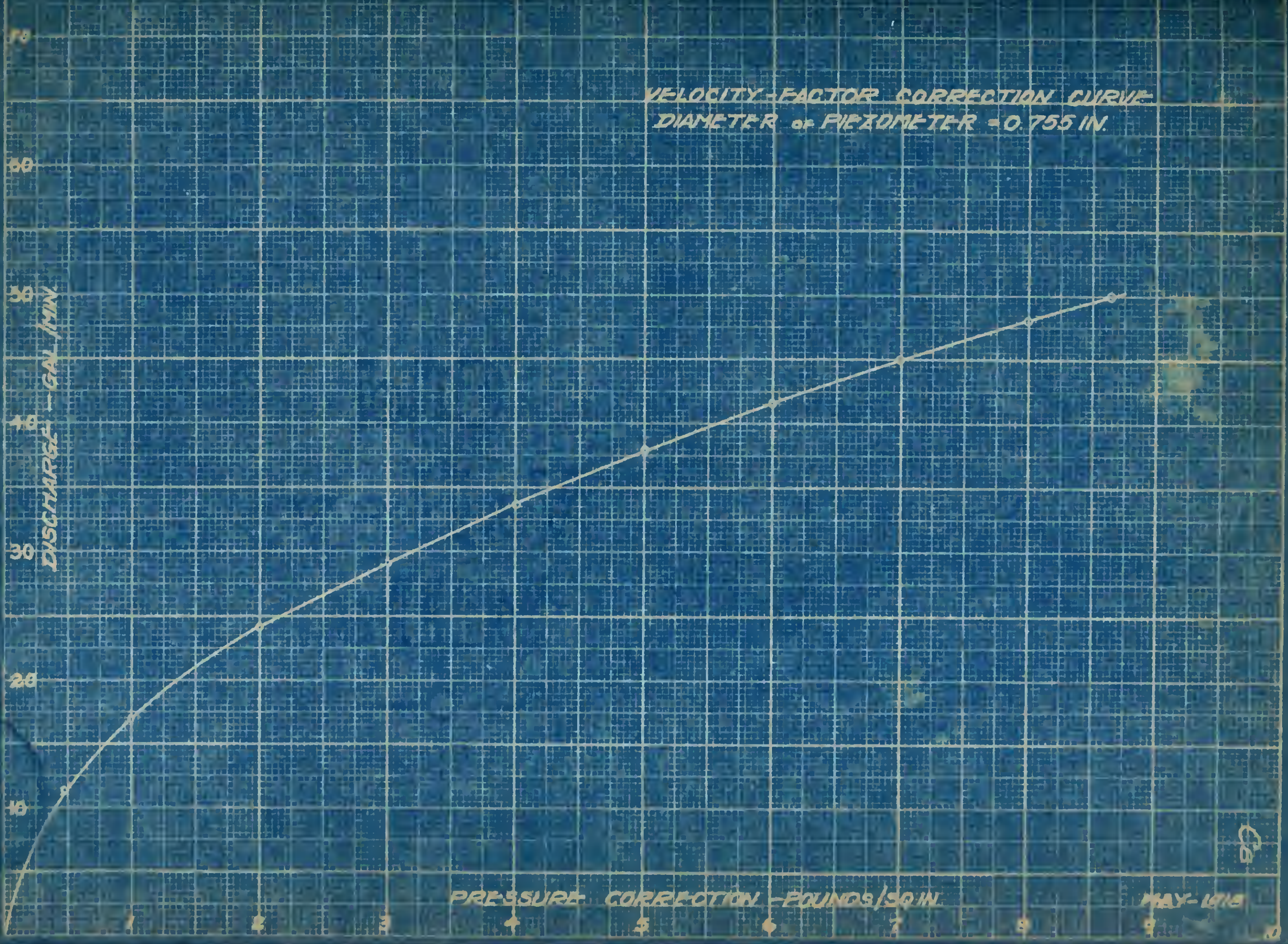
C6

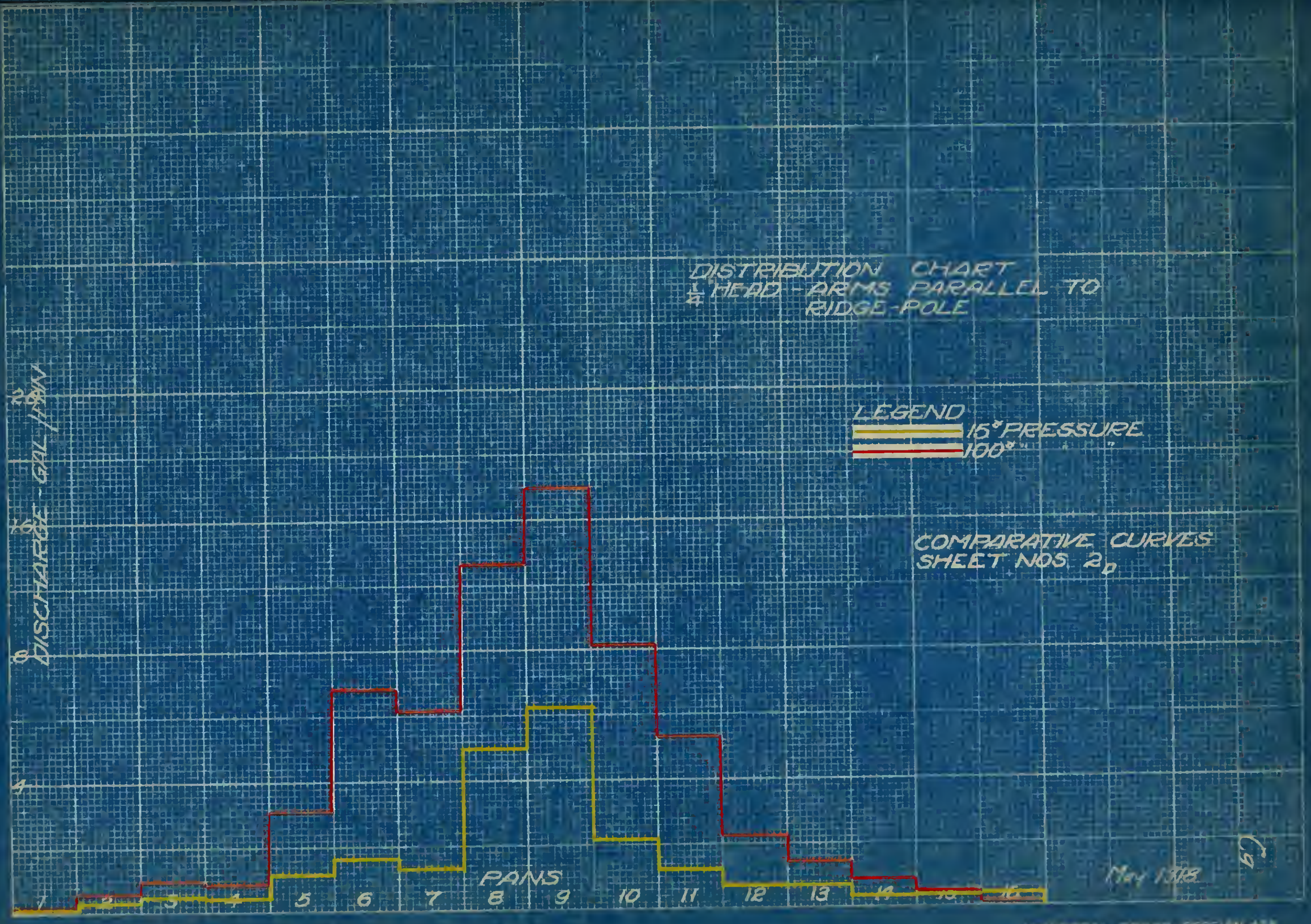


PRESSURE-DISCHARGE CURVES
$\frac{3}{8}$" HEAD - SHEET NOS. 1_a
ARMS PERPENDICULAR
TO RIDGE-POLE

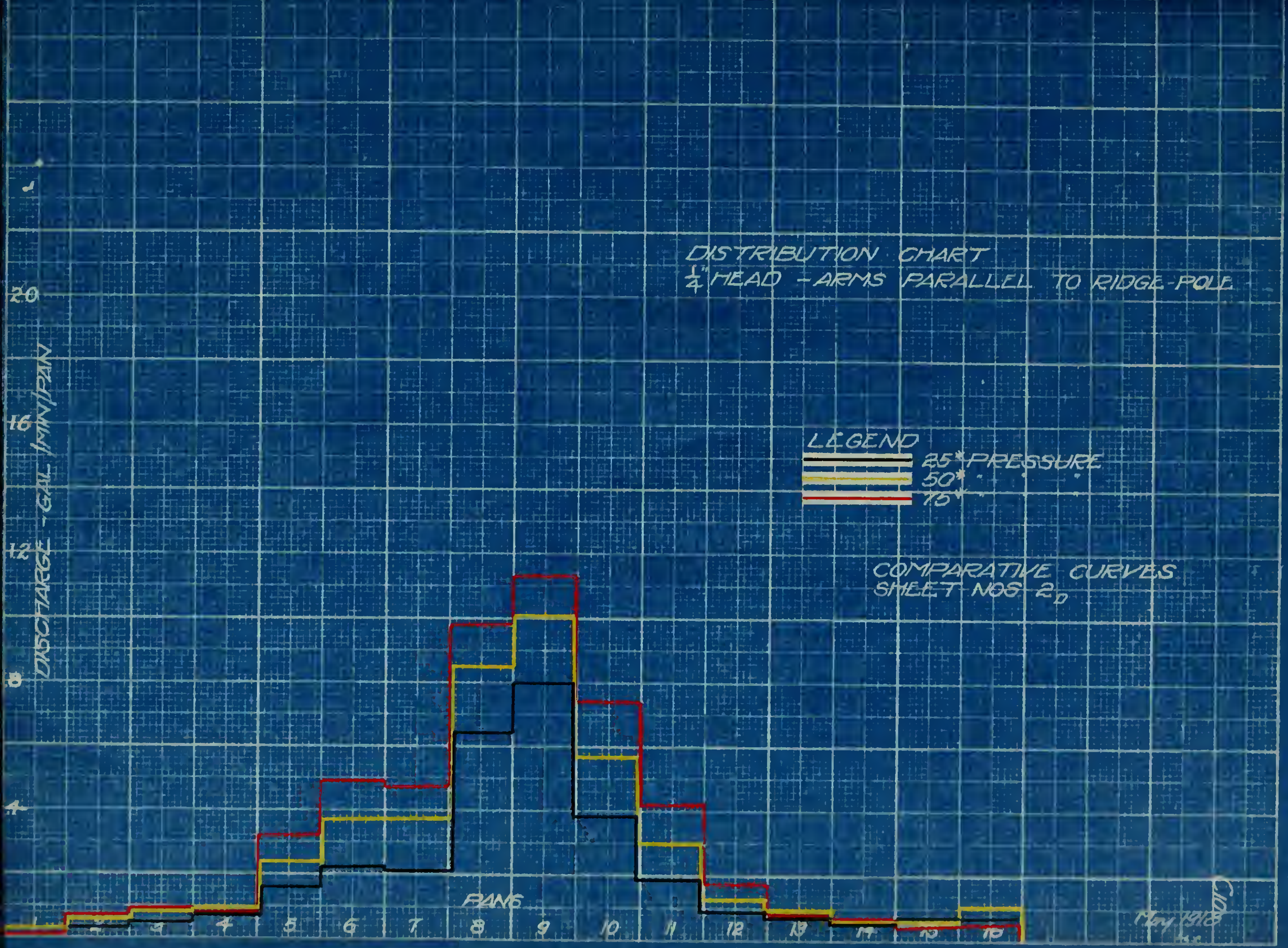
May - 1918


PRESSURE - DISCHARGE CURVES
A 3/8" HEAD
B 5/16" " "
C 1/4" " "
A
B
C
DISCHARGE - GAL/MIN
4
8
12
16
20
24
28
PRESSURE - LBS/SQ.IN
10
20
30
40
50
60
70
80
90
May-1918


VELOCITY-FACTOR CORRECTION CURVE
DIAMETER of PIEZOMETER = 0.755 IN.
DISCHARGE — GAL/MIN.
70
60
50
40
30
20
10
PRESSURE CORRECTION – POUNDS/SQ IN.
1
2
3
4
5
6
7
8
9
10
MAY-1916
CB



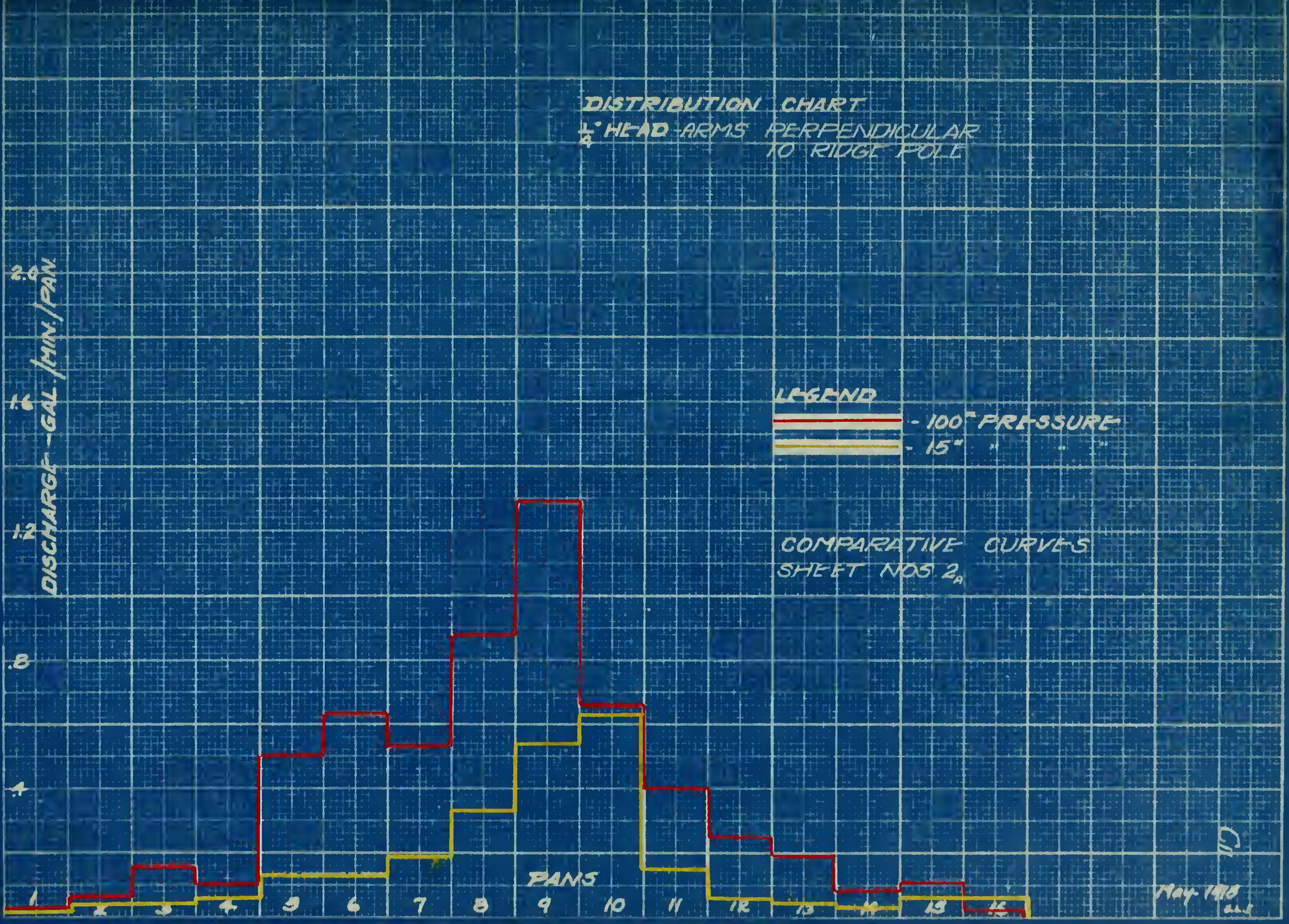
UNIVERSAL CROSS SECTION 435



DISTRIBUTION CHART
$\frac{1}{4}$" HEAD - ARMS PARALLEL TO RIDGE-POLE

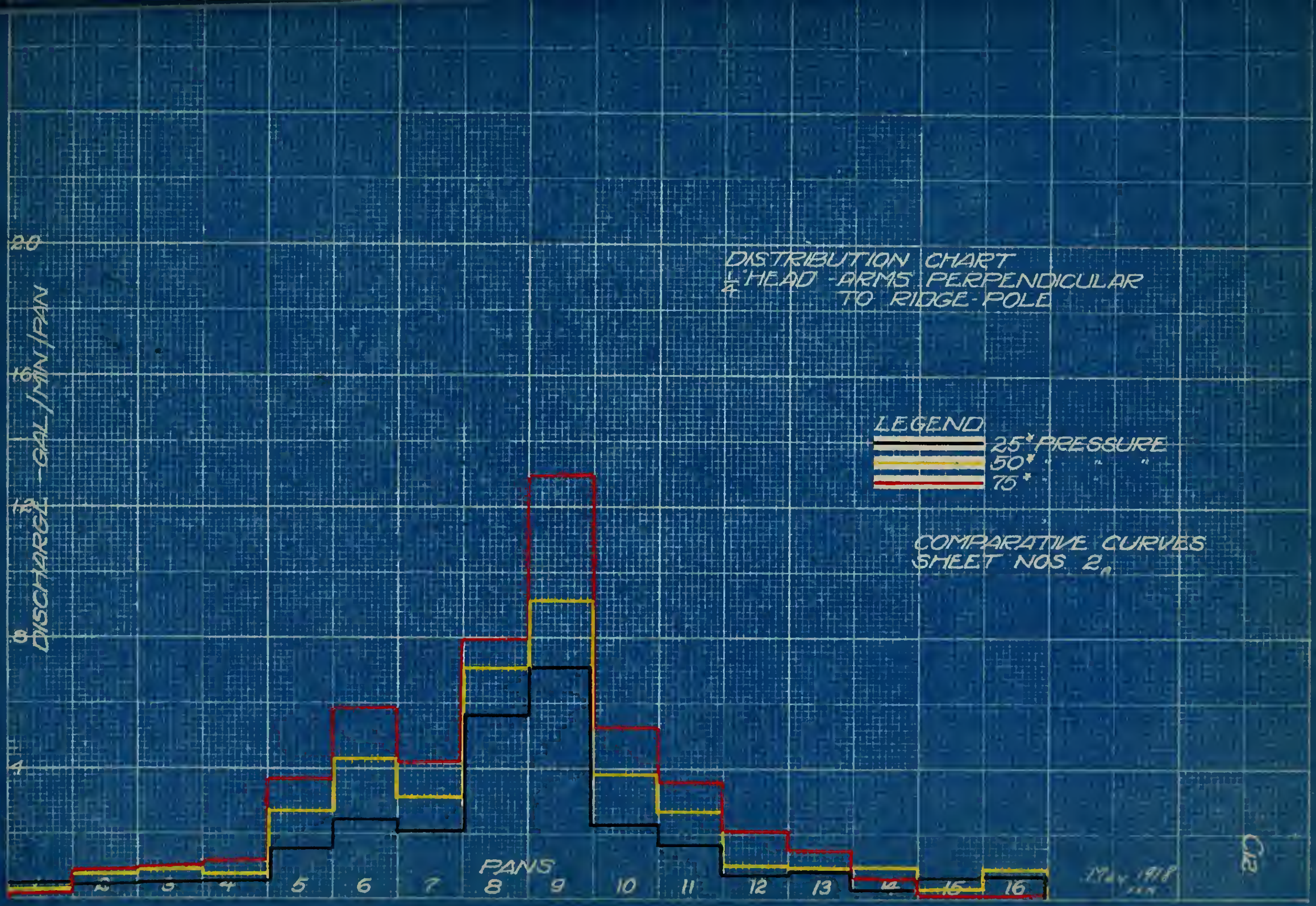
COMPARATIVE CURVES
SHEET NOS. 2_D

C108
May 1918


DISTRIBUTION CHART
1/4" HEAD-ARMS PERPENDICULAR TO RIDGE POLE

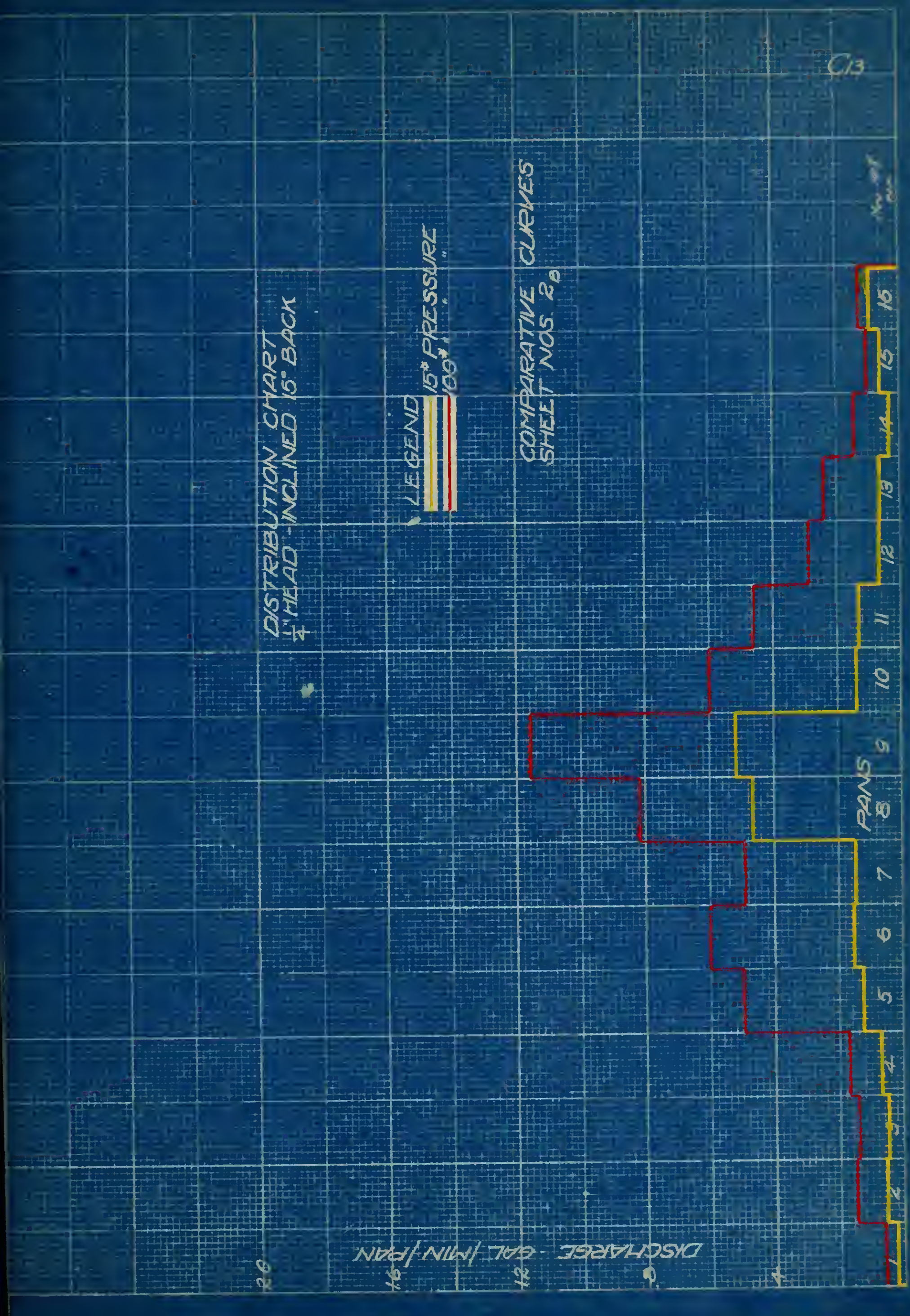
COMPARATIVE CURVES
SHEET NOS 2a

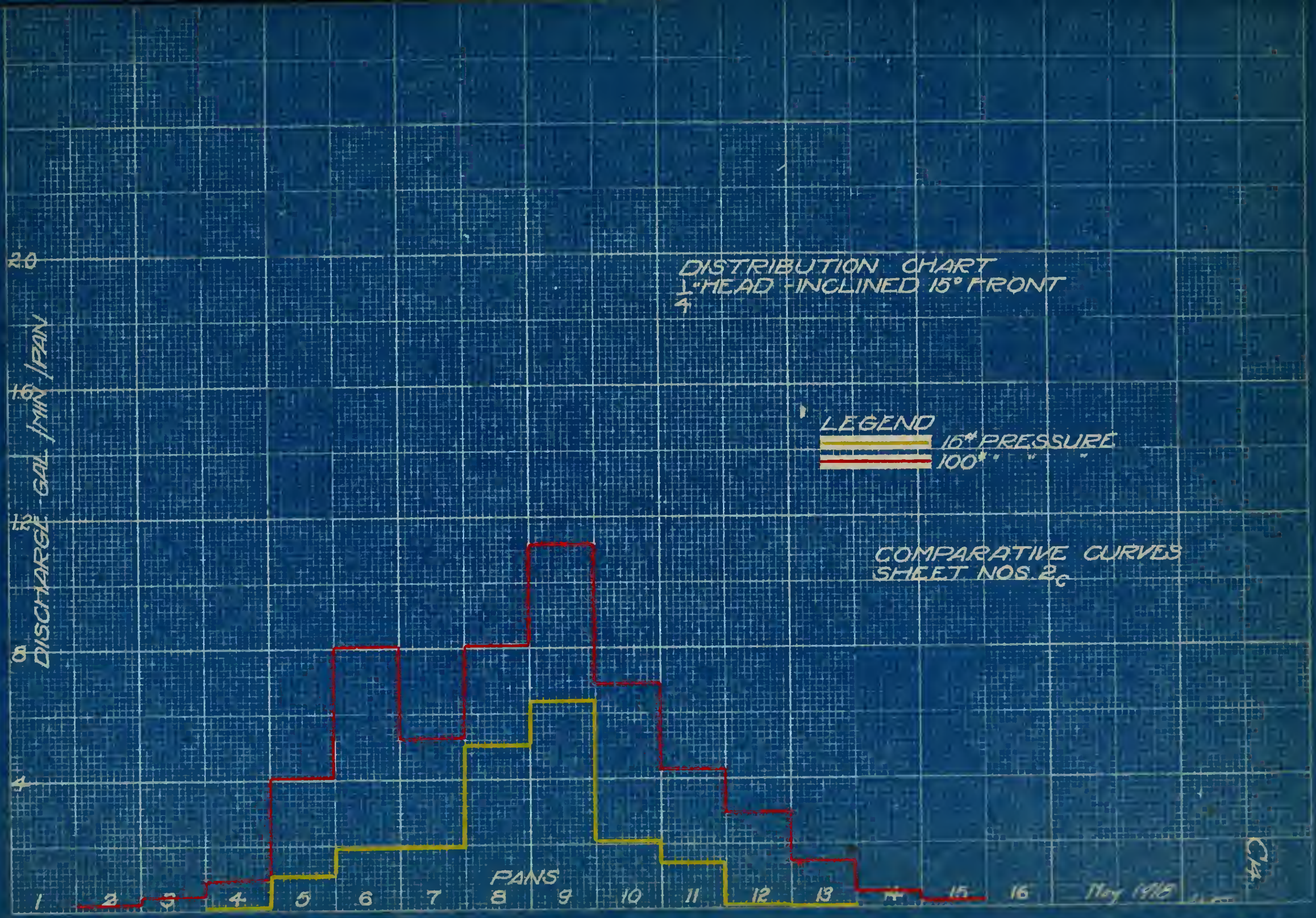
May 1918



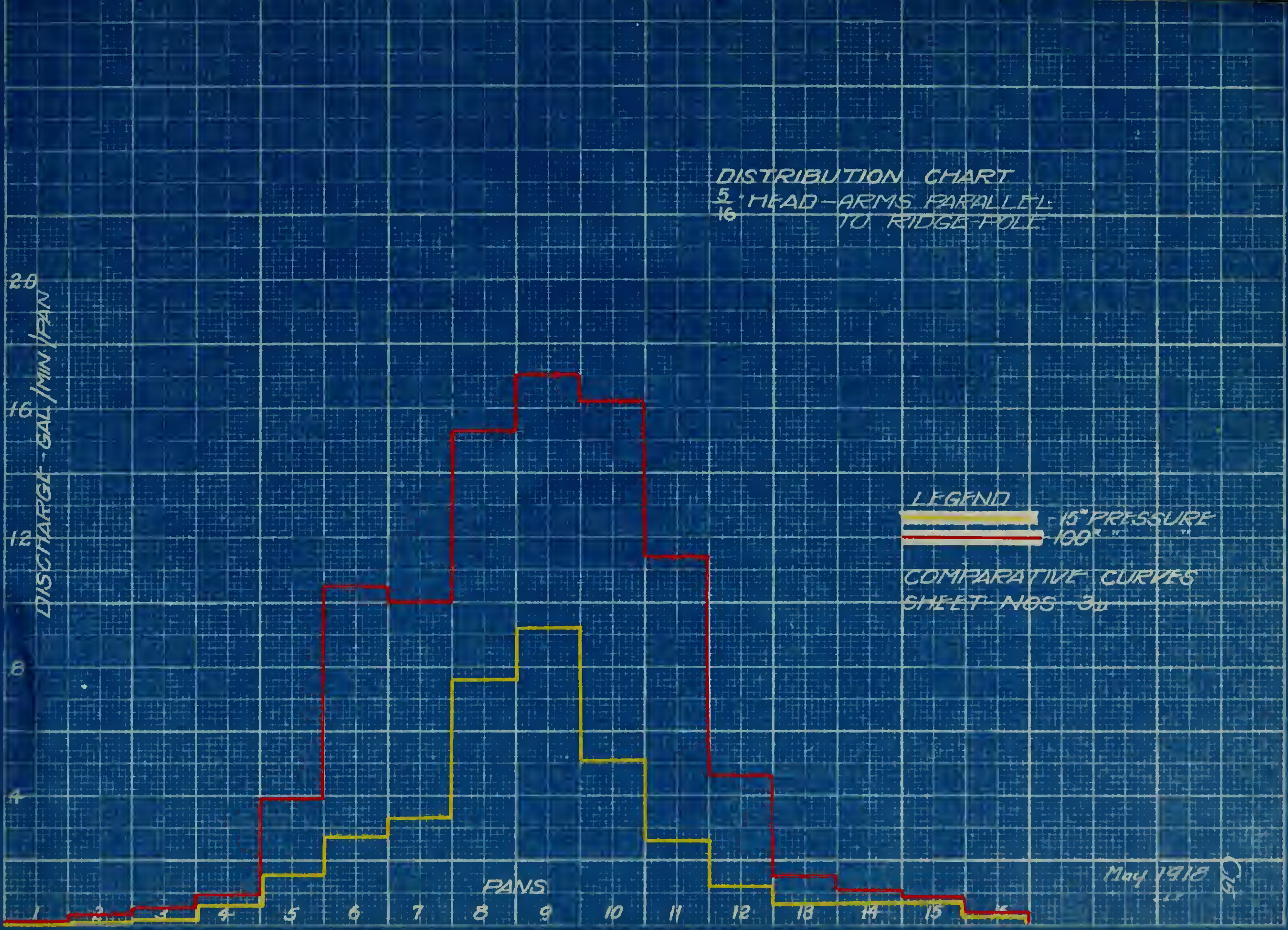
UNIVERSAL CROSS SECTION 459

C13


DISTRIBUTION CHART
1/4" HEAD - INCLINED 15° BACK
LEGEND
🟨 15# PRESSURE
🟥 100# "
COMPARATIVE CURVES
SHEET NOS. 2B
DISCHARGE - GAL./MIN./PAN
20
16
12
8
4
PANS
No. of Pan
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

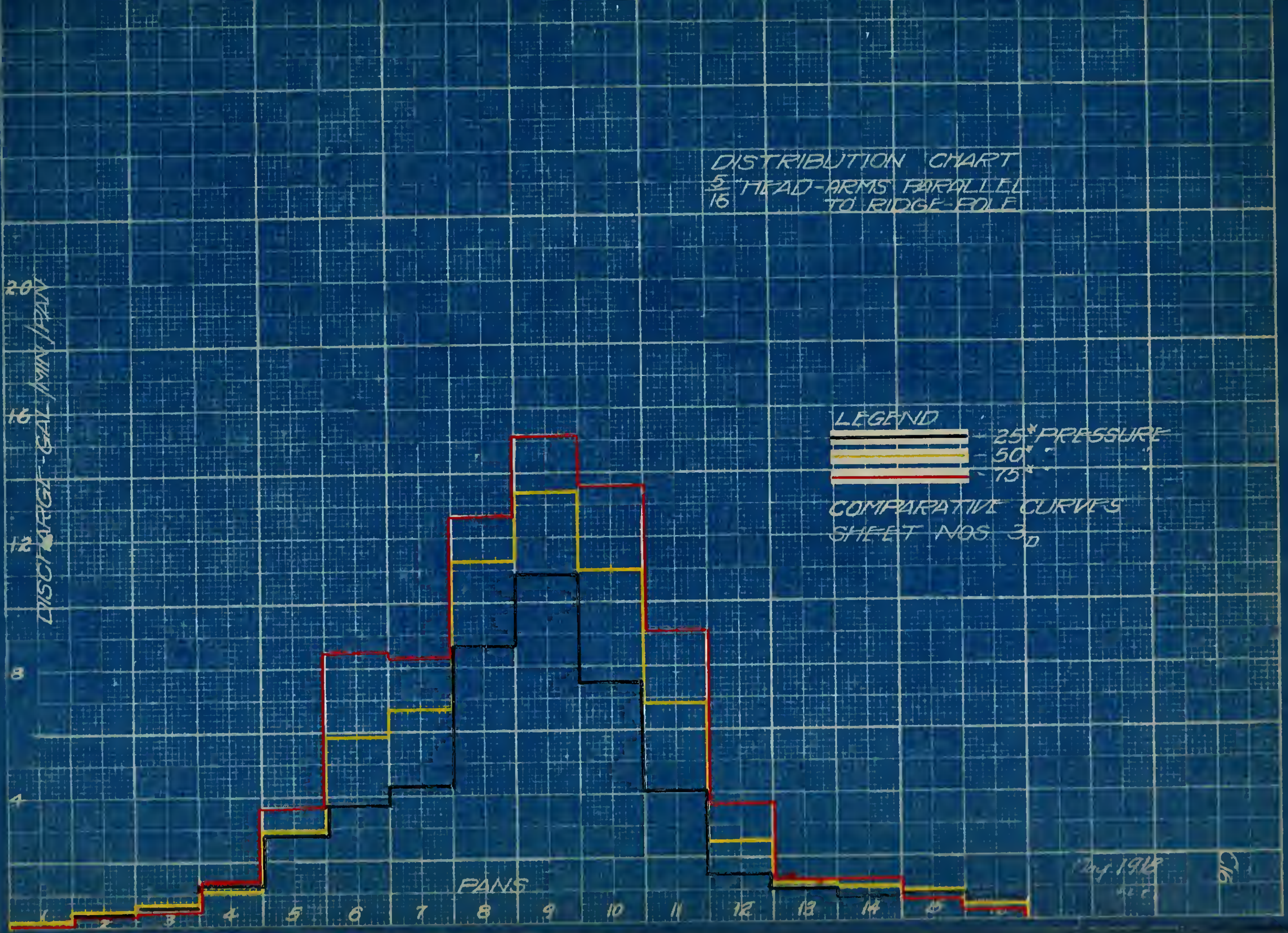


UNIVERSAL CROSS SECTION 435



DISTRIBUTION CHART

$\frac{5}{16}$" HEAD—ARMS PARALLEL TO RIDGE POLE

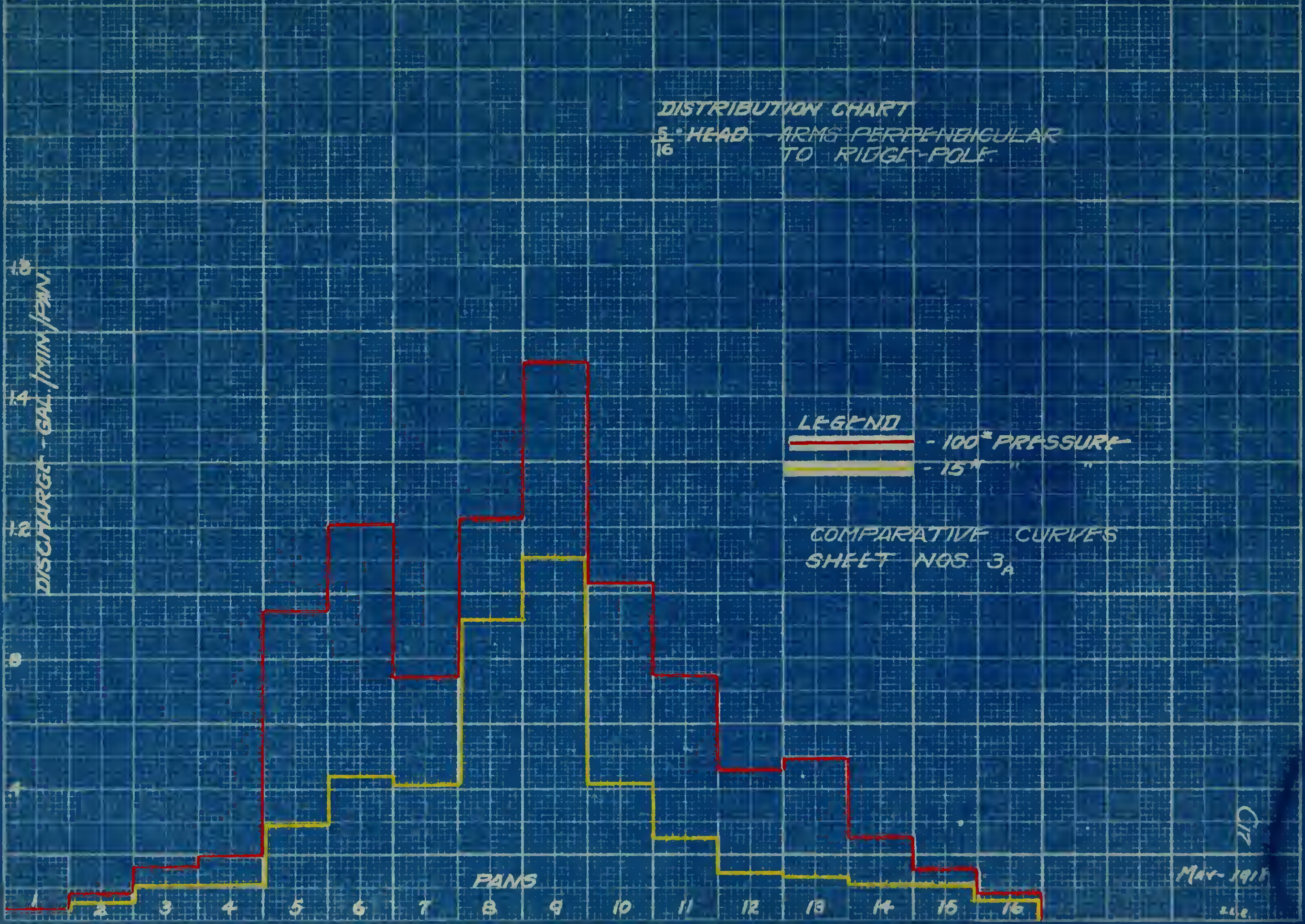


DISTRIBUTION CHART

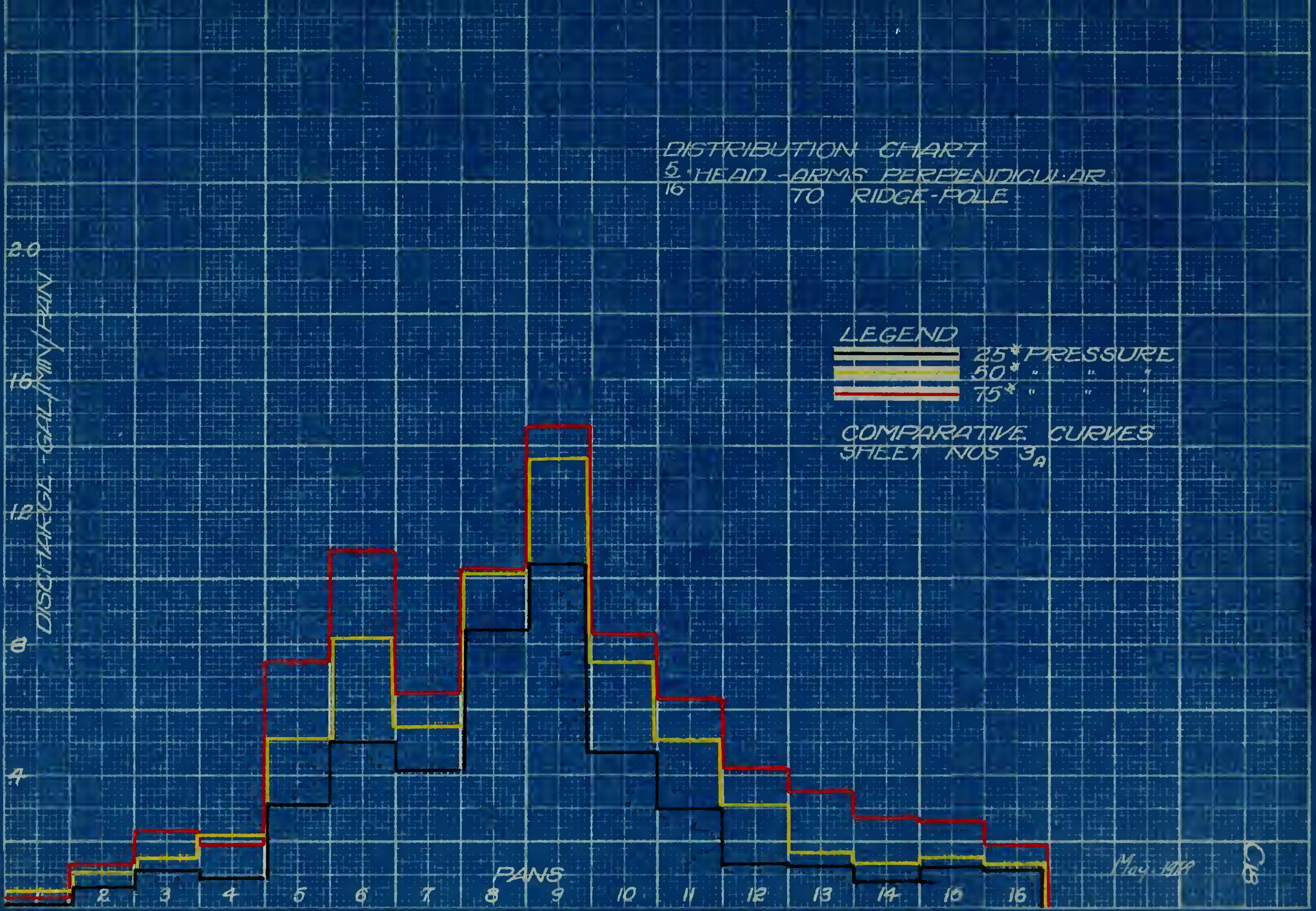
$\frac{5}{16}$" HEAD-ARMS PARALLEL TO RIDGE-POLE

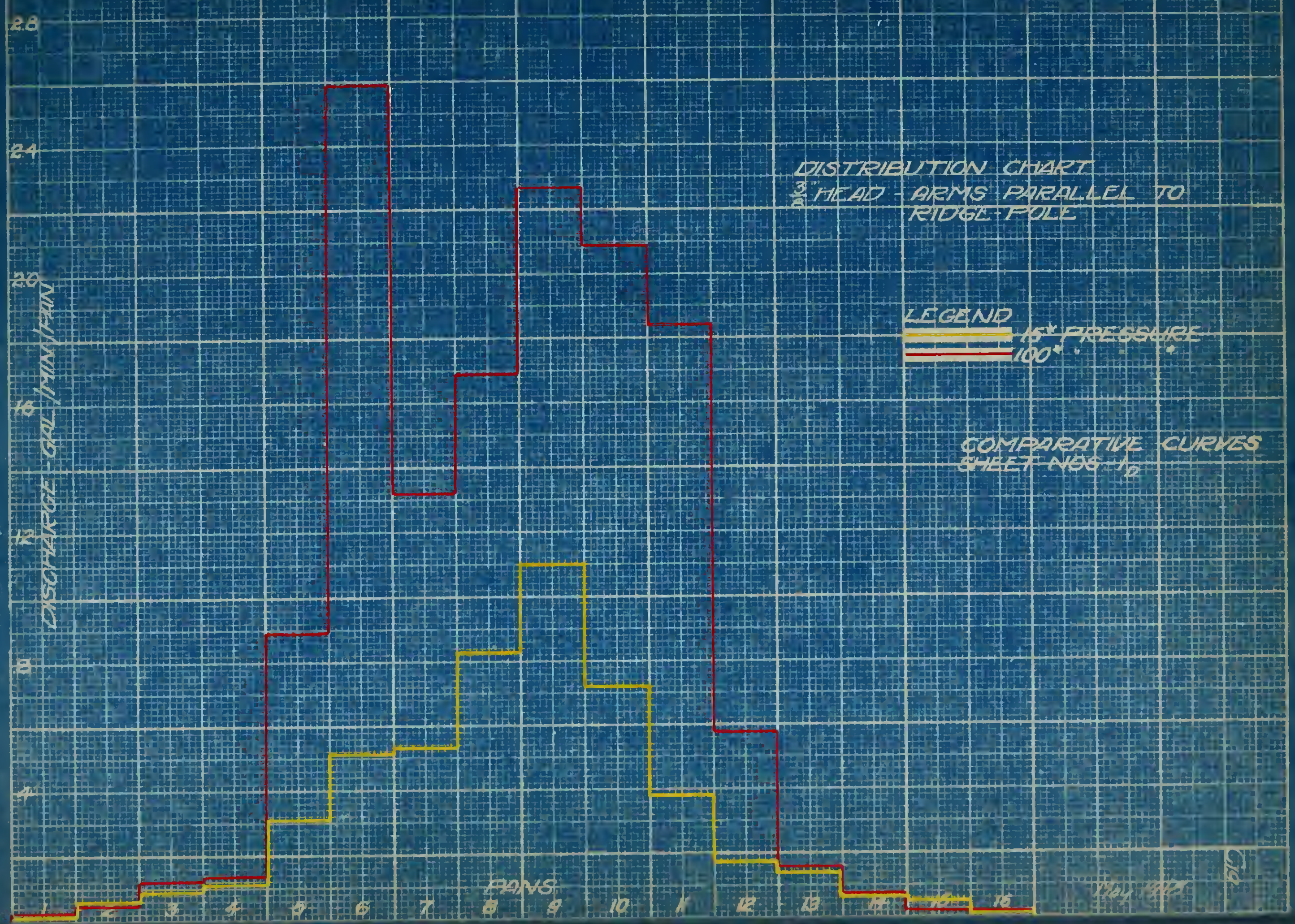
COMPARATIVE CURVES

SHEET NOS 3_D



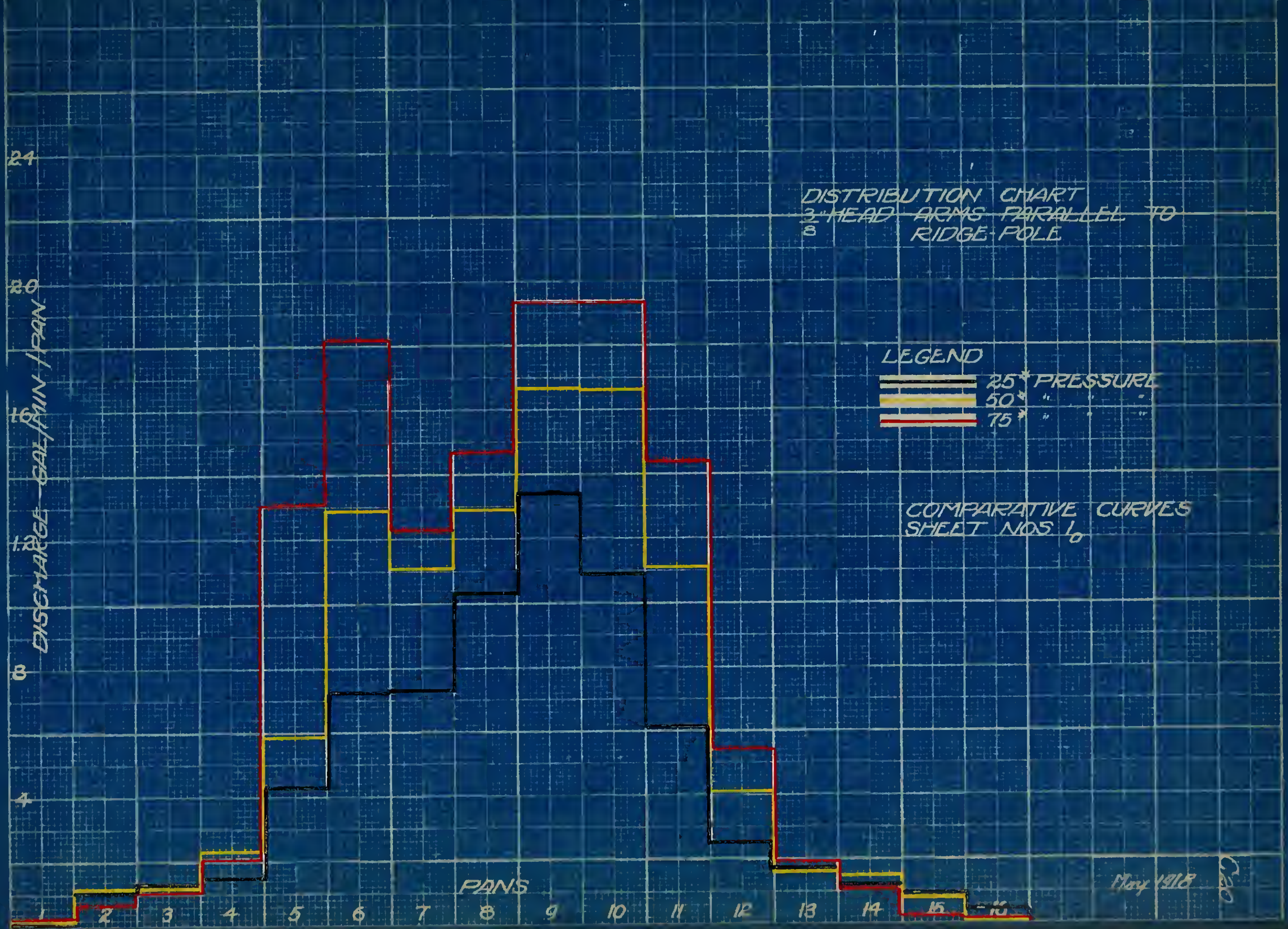
UNIVERSAL CROSS SECTION 451





DISTRIBUTION CHART
3/8" HEAD - ARMS PARALLEL TO
RIDGE POLE

COMPARATIVE CURVES
SHEET NOS. 1/2

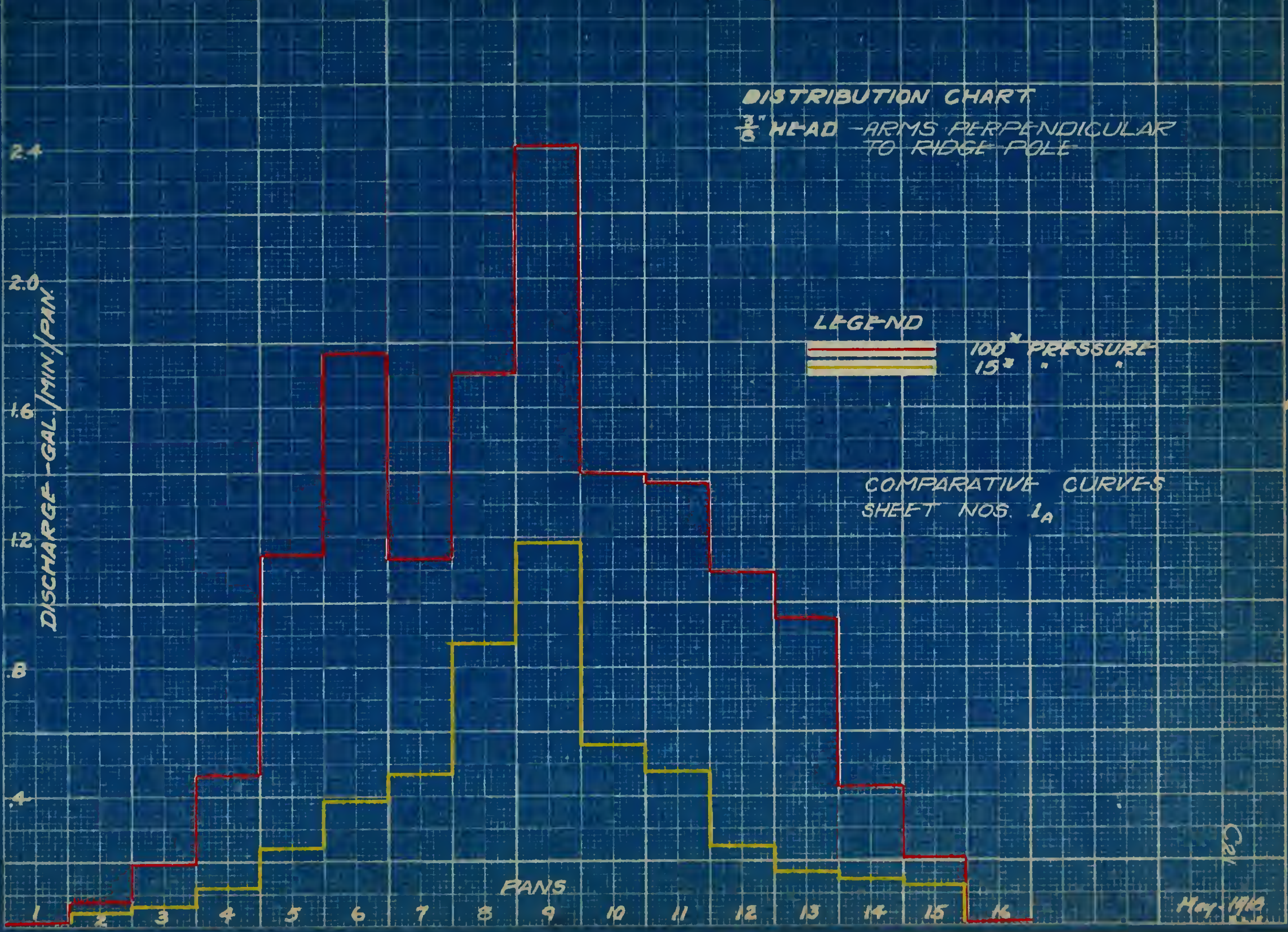


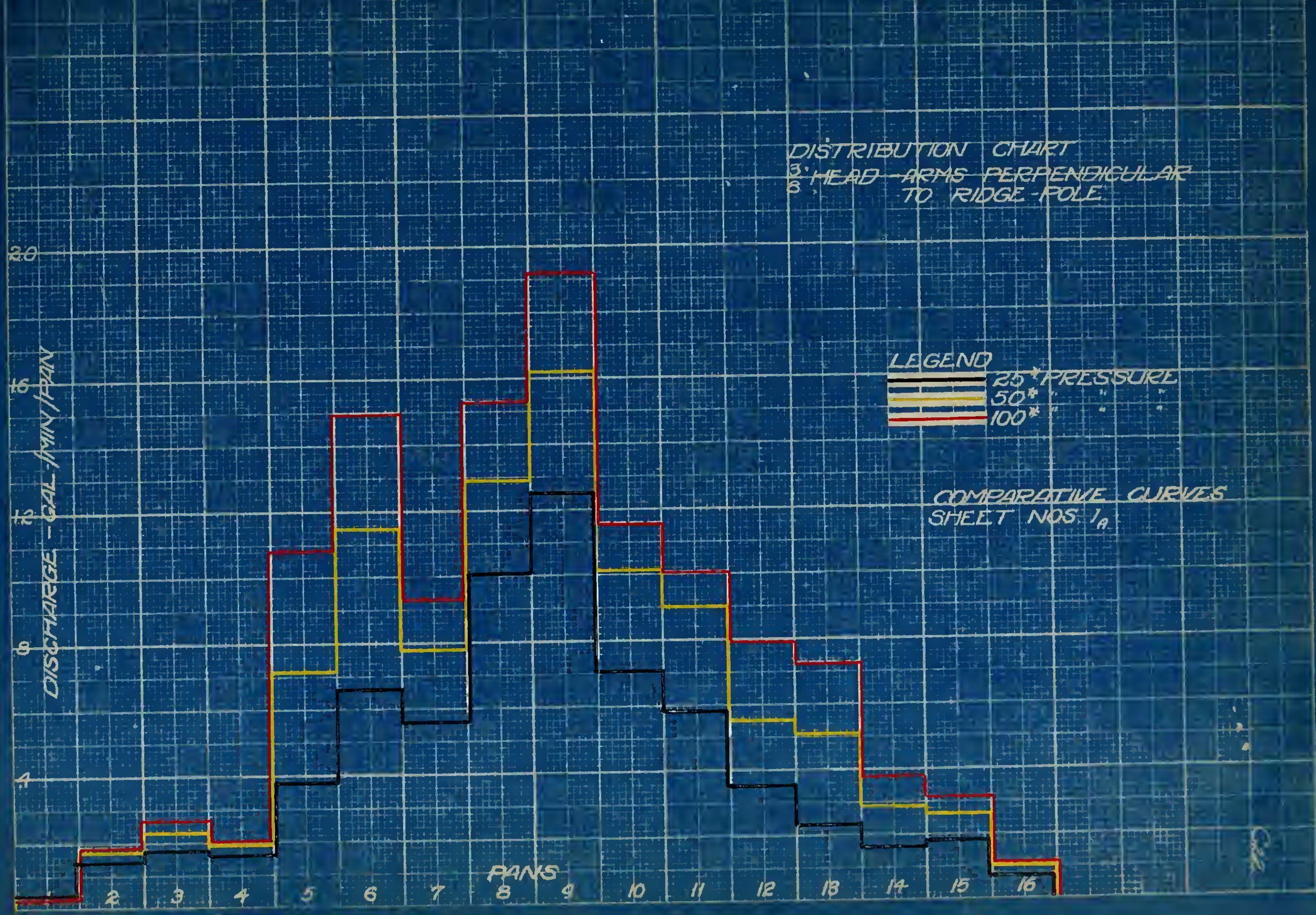
DISTRIBUTION CHART
3/8" HEAD ARMS PARALLEL TO RIDGE POLE

COMPARATIVE CURVES
SHEET NOS 10

May 1918

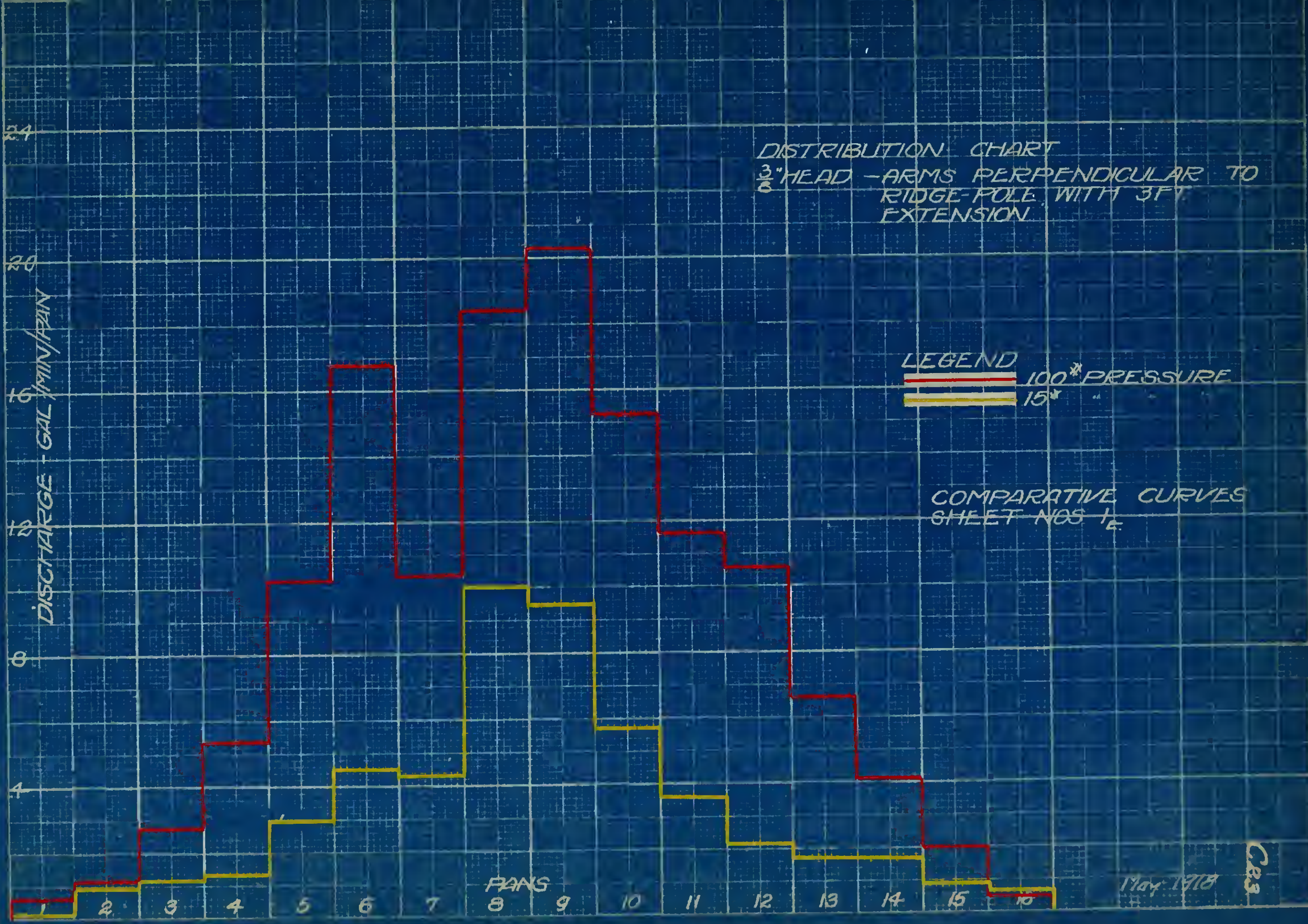
C30


DISTRIBUTION CHART
3/8" HEAD - ARMS PERPENDICULAR TO RIDGE POLE
LEGEND
100# PRESSURE
15# " "
COMPARATIVE CURVES
SHEET NOS. 1A
DISCHARGE - GAL./MIN./PAN.
2.4
2.0
1.6
1.2
.8
.4
PANS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Cal
May - 1910



DISTRIBUTION CHART
3/8" HEAD - ARMS PERPENDICULAR
TO RIDGE-POLE

COMPARATIVE CURVES
SHEET NOS. 1A

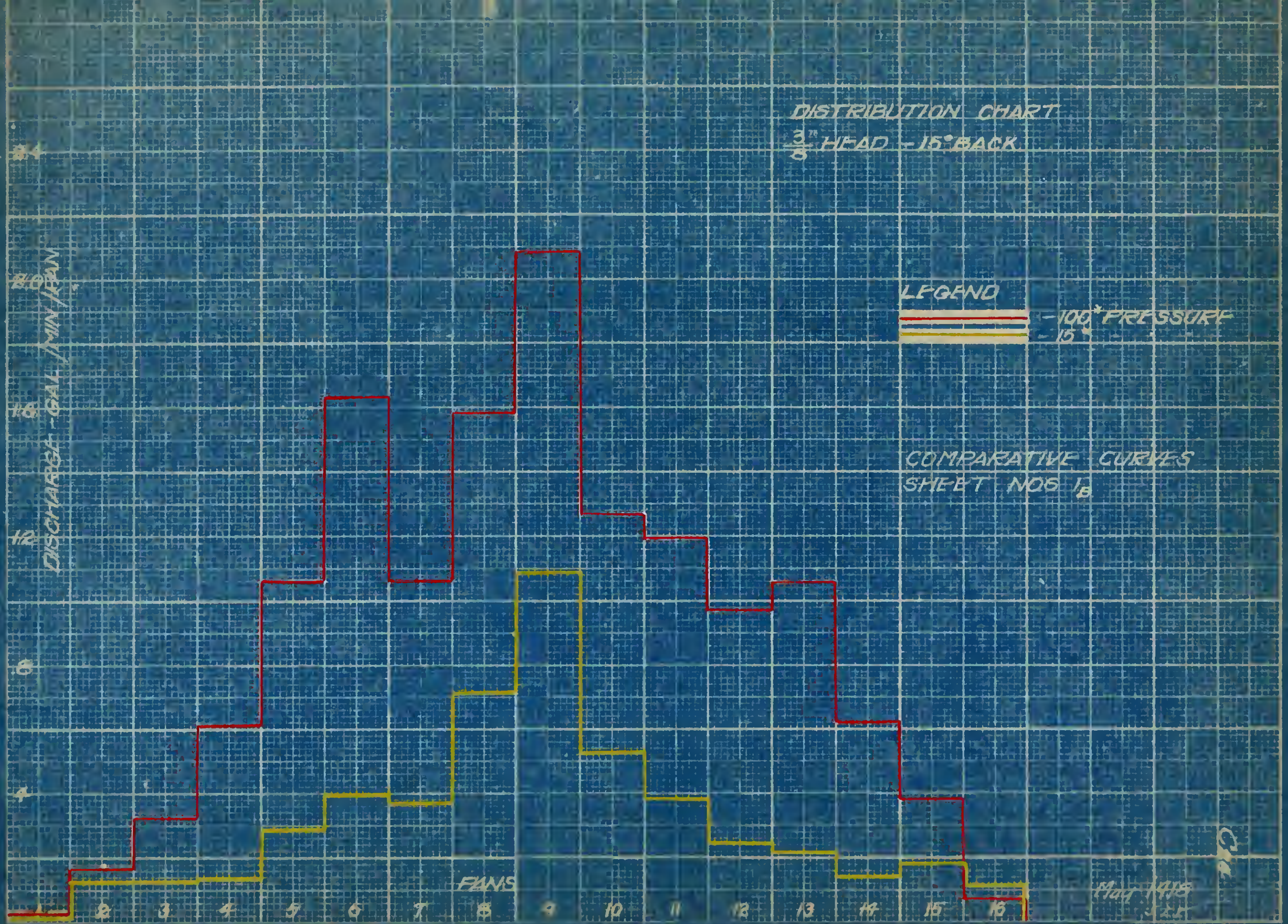


DISTRIBUTION CHART
$\frac{3}{8}$" HEAD – ARMS PERPENDICULAR TO RIDGE-POLE WITH 3 FT EXTENSION

COMPARATIVE CURVES
SHEET NOS 1/2

May 1918

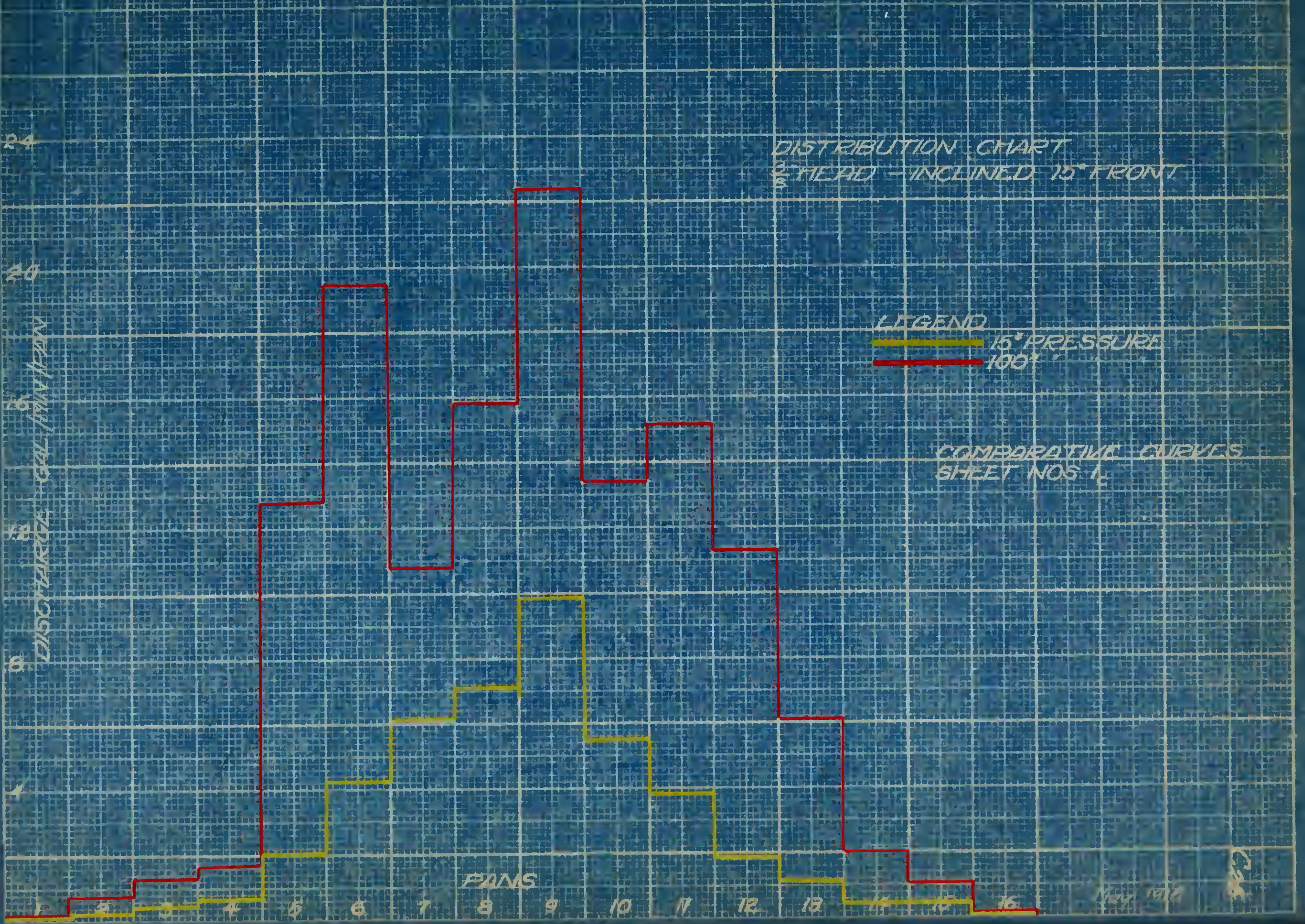
C23

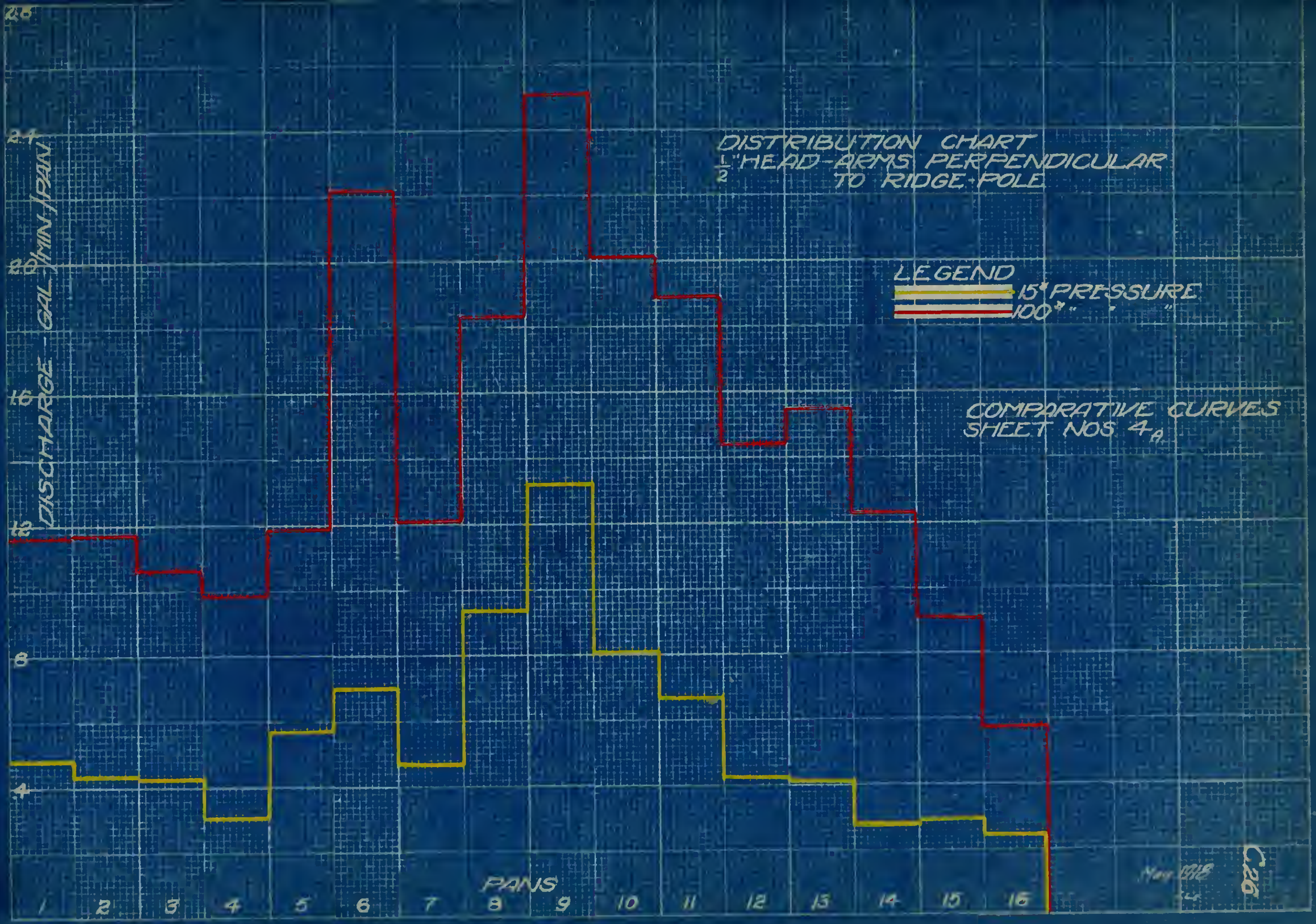


DISTRIBUTION CHART

$\frac{3}{8}$" HEAD - 15° BACK

COMPARATIVE CURVES
SHEET NOS 1/8

DISTRIBUTION CHART
⅔ HEAD - INCLINED 15° FRONT
LEGEND
15# PRESSURE
100# "
COMPARATIVE CURVES
SHEET NOS 1
DISCHARGE - GAL/MIN/PAN
4
8
12
16
20
24
PANS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
MAY 1914

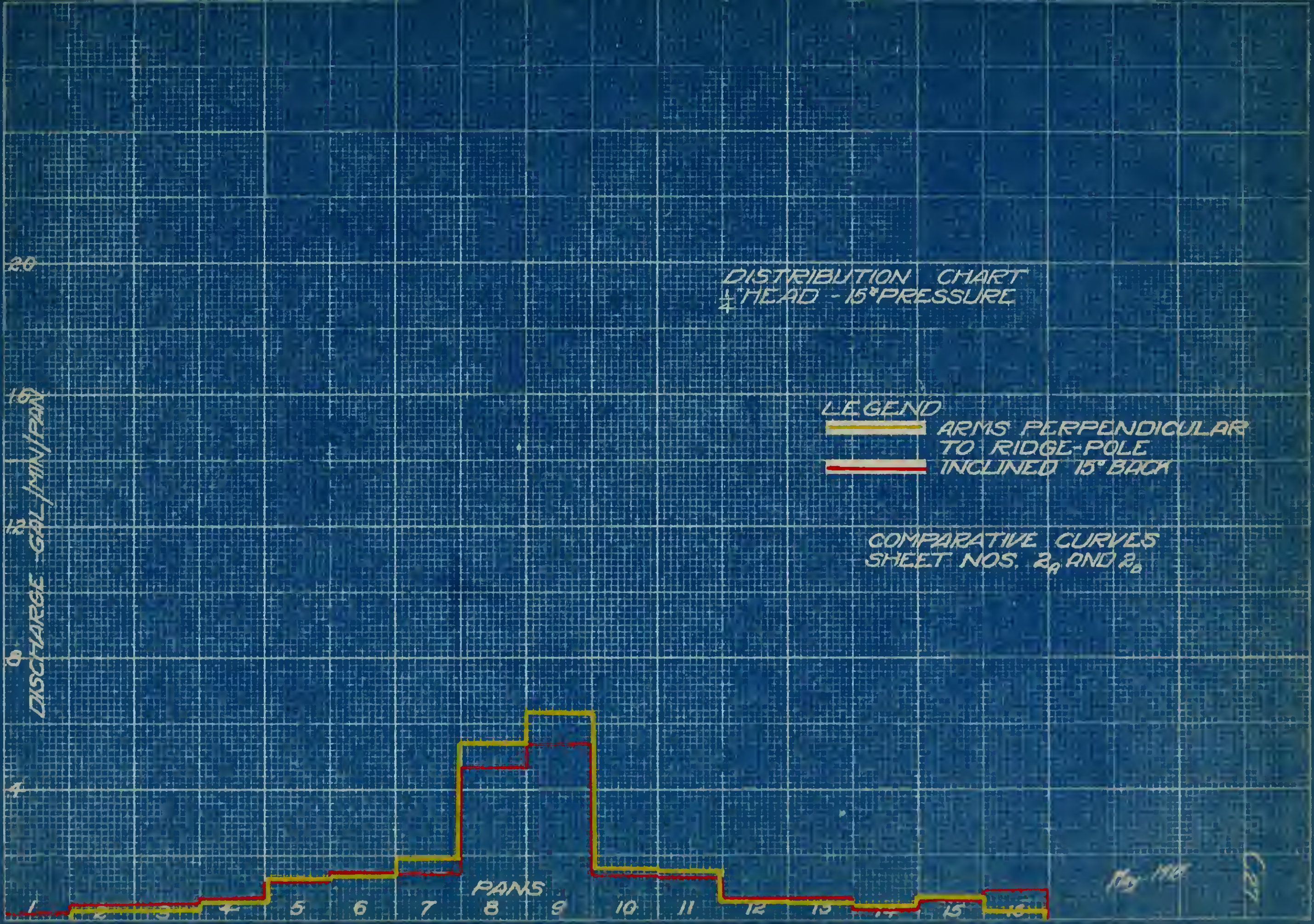

DISTRIBUTION CHART
½" HEAD-ARMS PERPENDICULAR
TO RIDGE-POLE

COMPARATIVE CURVES
SHEET NOS 4A

May 1918

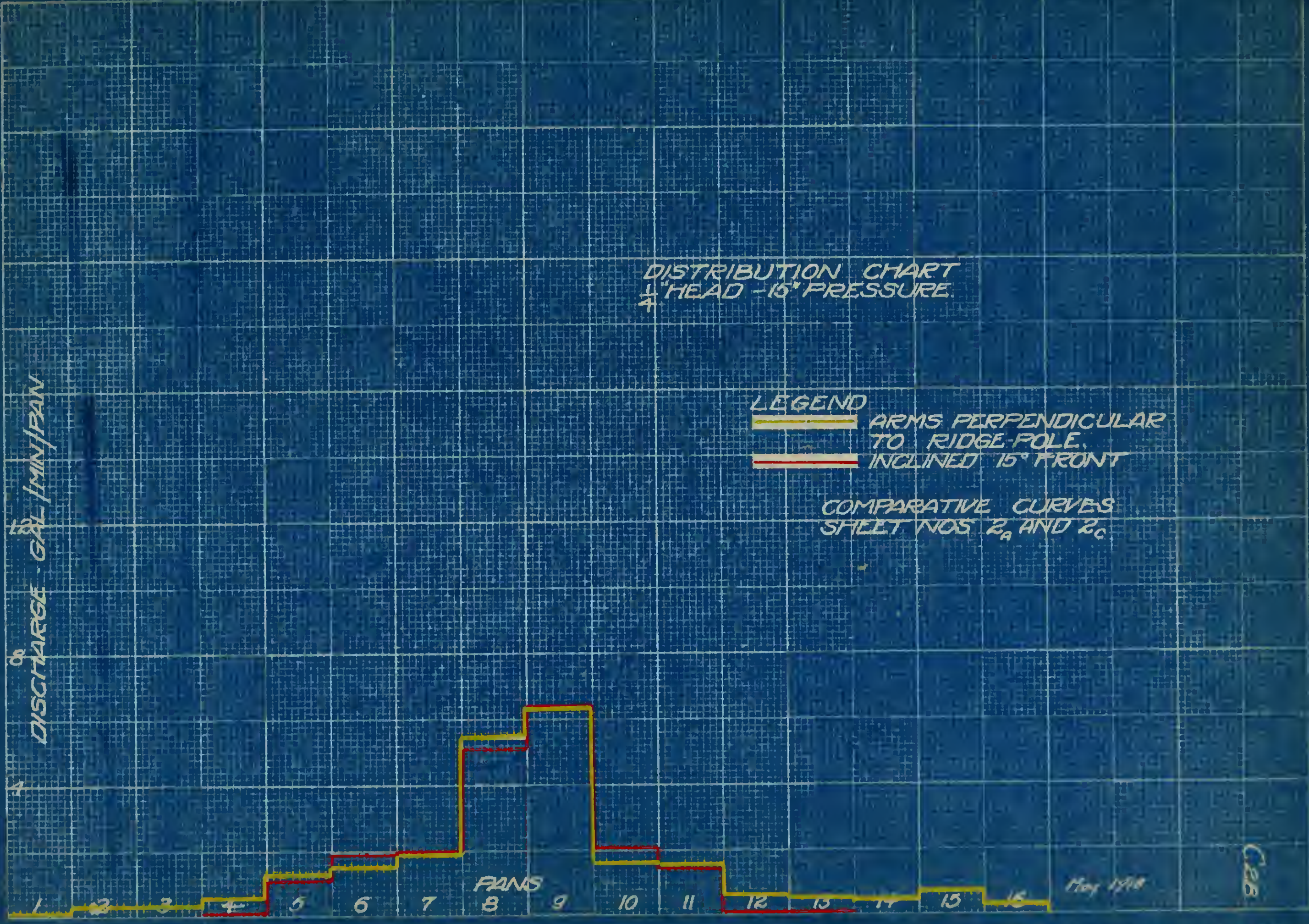
C26

UNIVERSAL CROSS SECTION 455

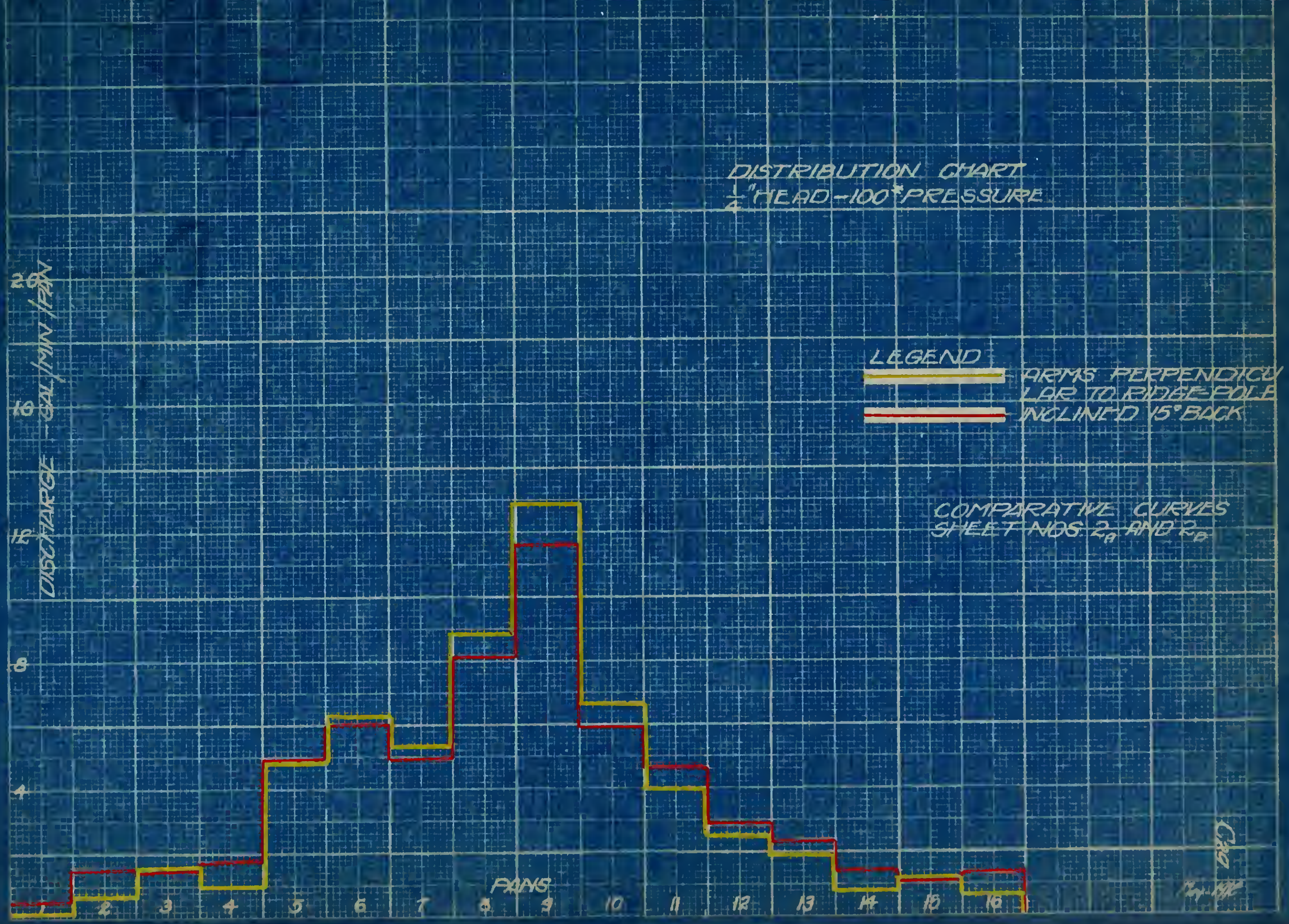


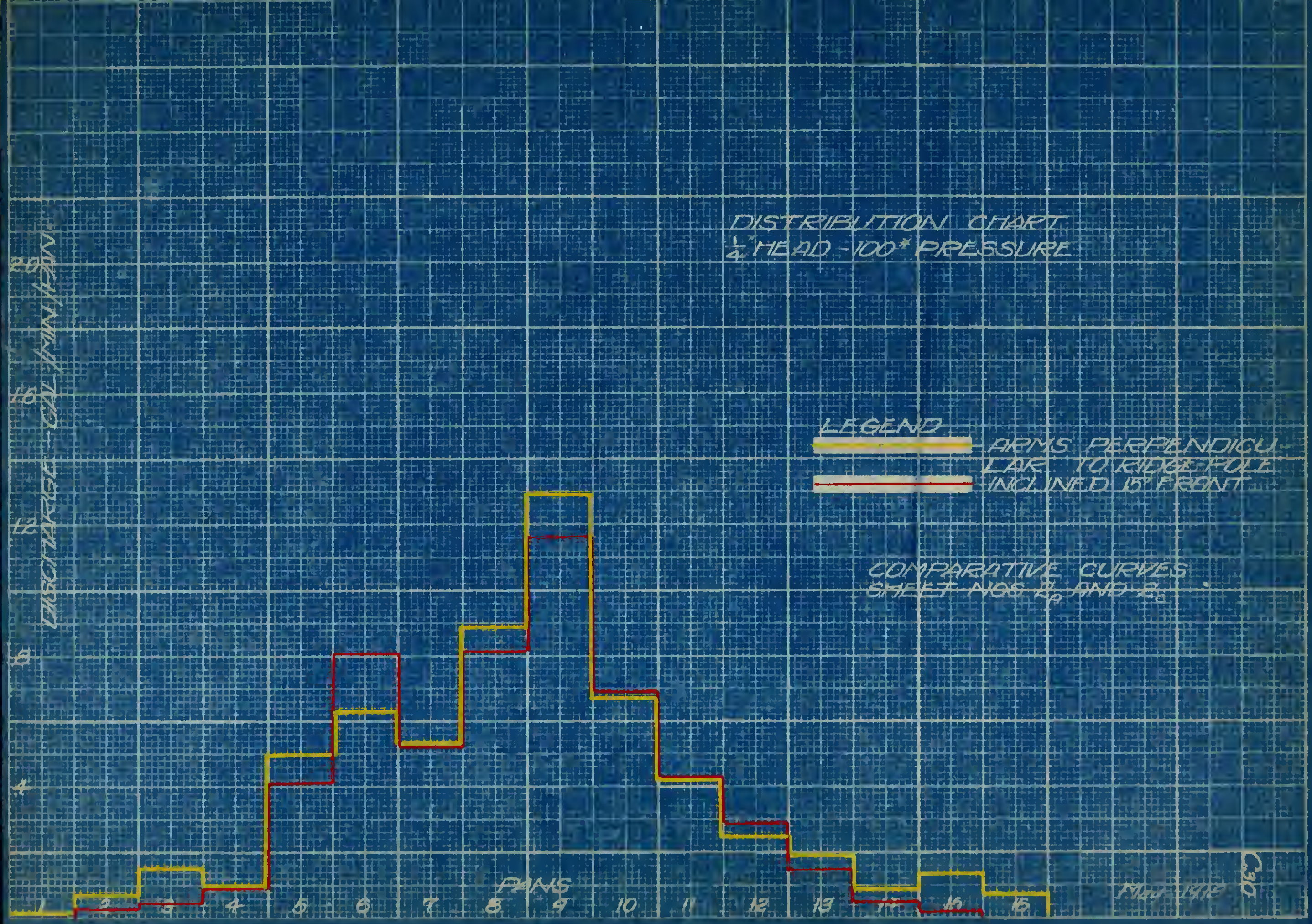
C27

UNIVERSAL CROSS SECTION 458

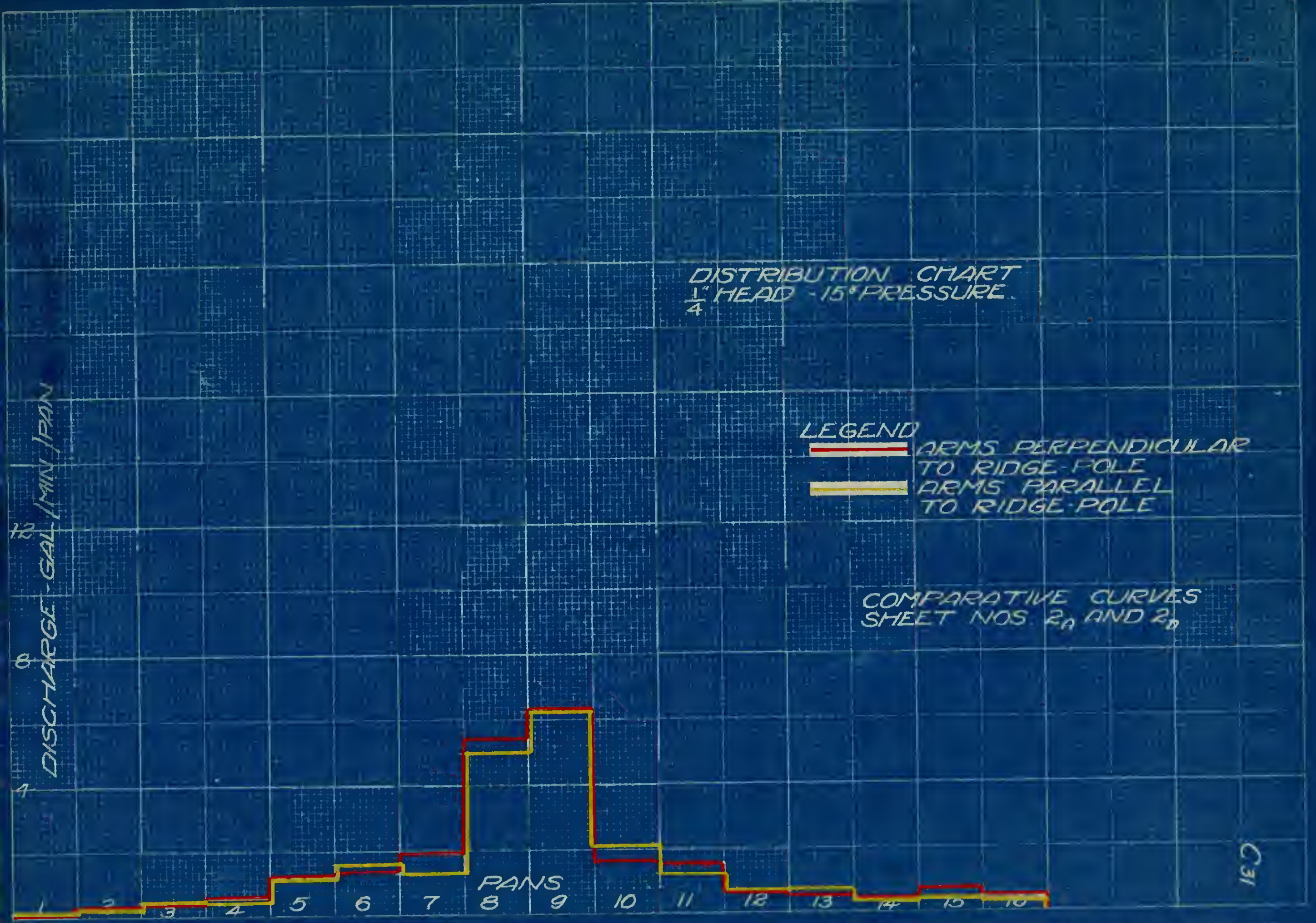


UNIVERSAL CROSS SECTION 459

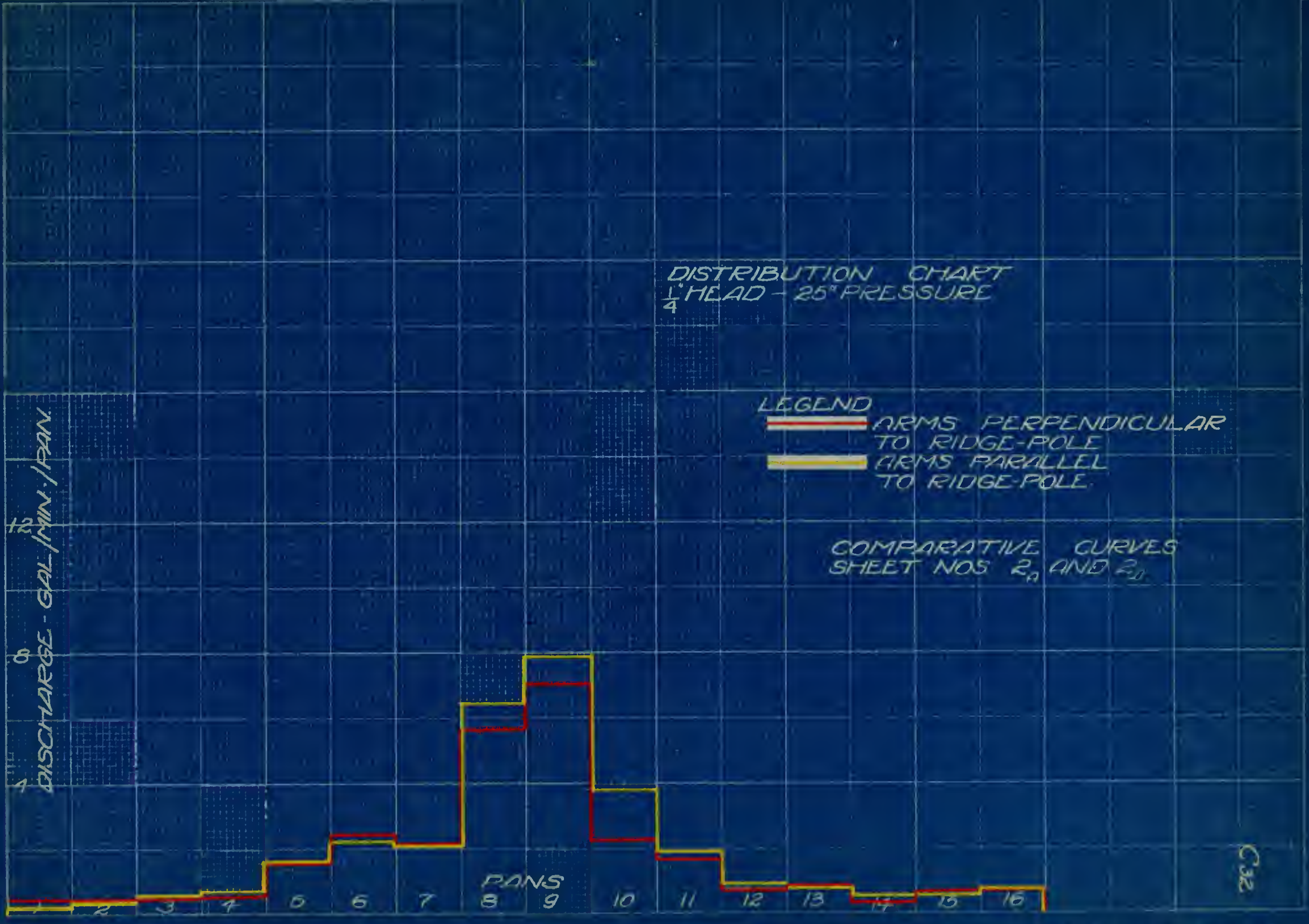

DISTRIBUTION CHART
$\frac{1}{4}$" HEAD - 100# PRESSURE
LEGEND
ARMS PERPENDICU
LAR TO RIDGE-POLE
INCLINED 15° BACK
COMPARATIVE CURVES
SHEET NOS. 2_a AND 2_b
DISCHARGE - GAL/MIN/PAN
20
16
12
8
4
PANS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
C39



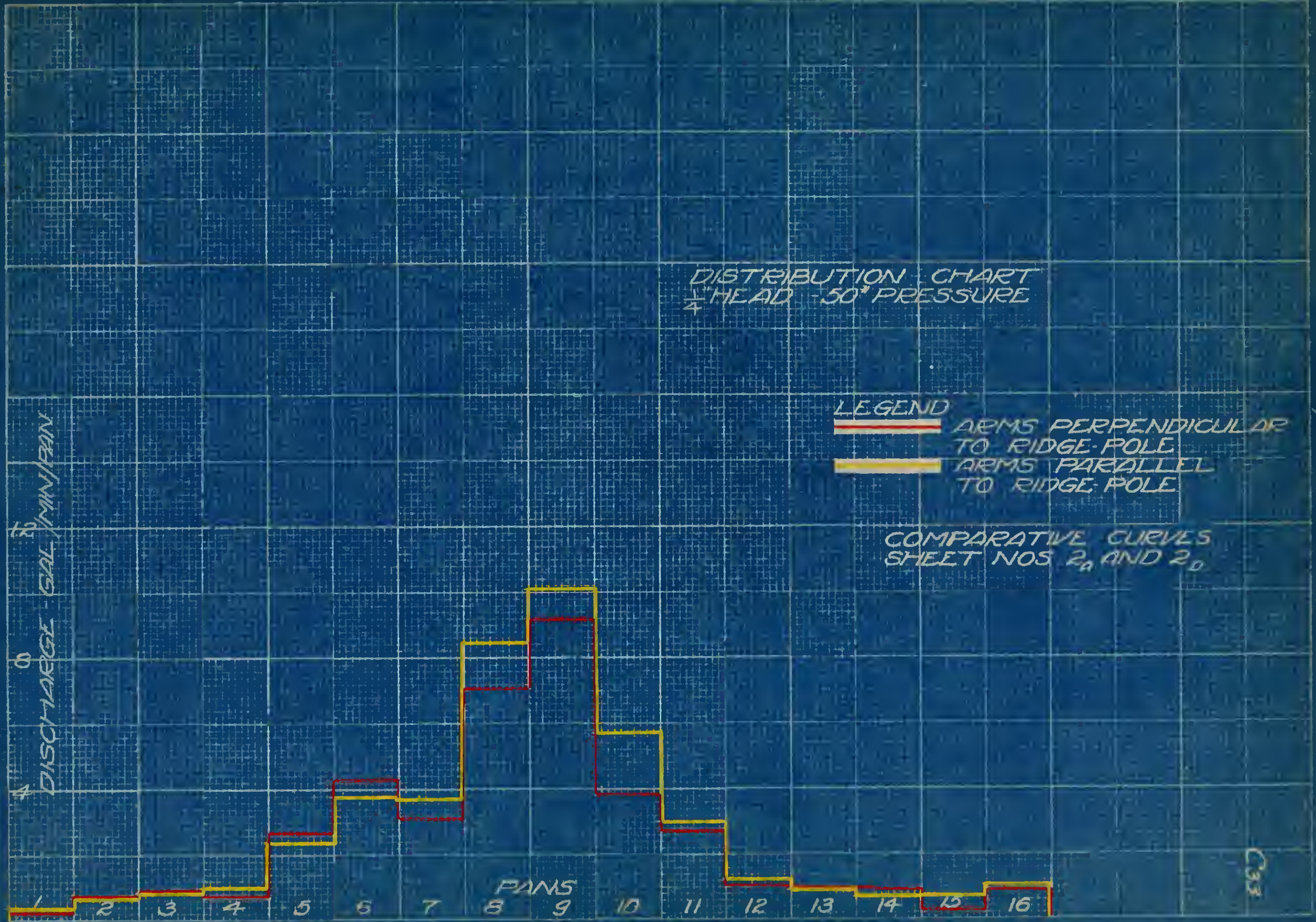
UNIVERSAL CROSS SECTION 451



UNIVERSAL CROSS SECTION 453

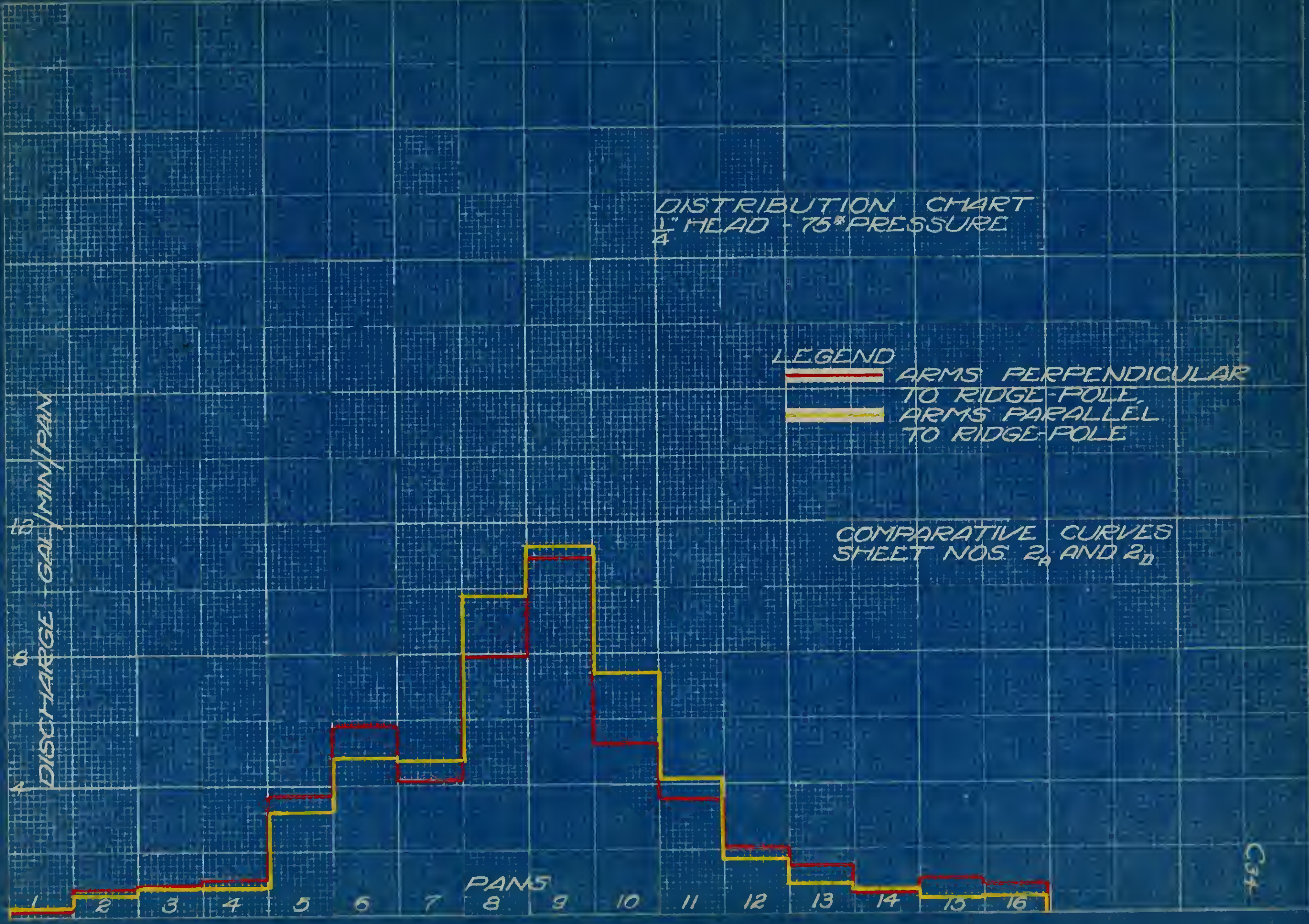


UNIVERSAL CROSS SECTION 342



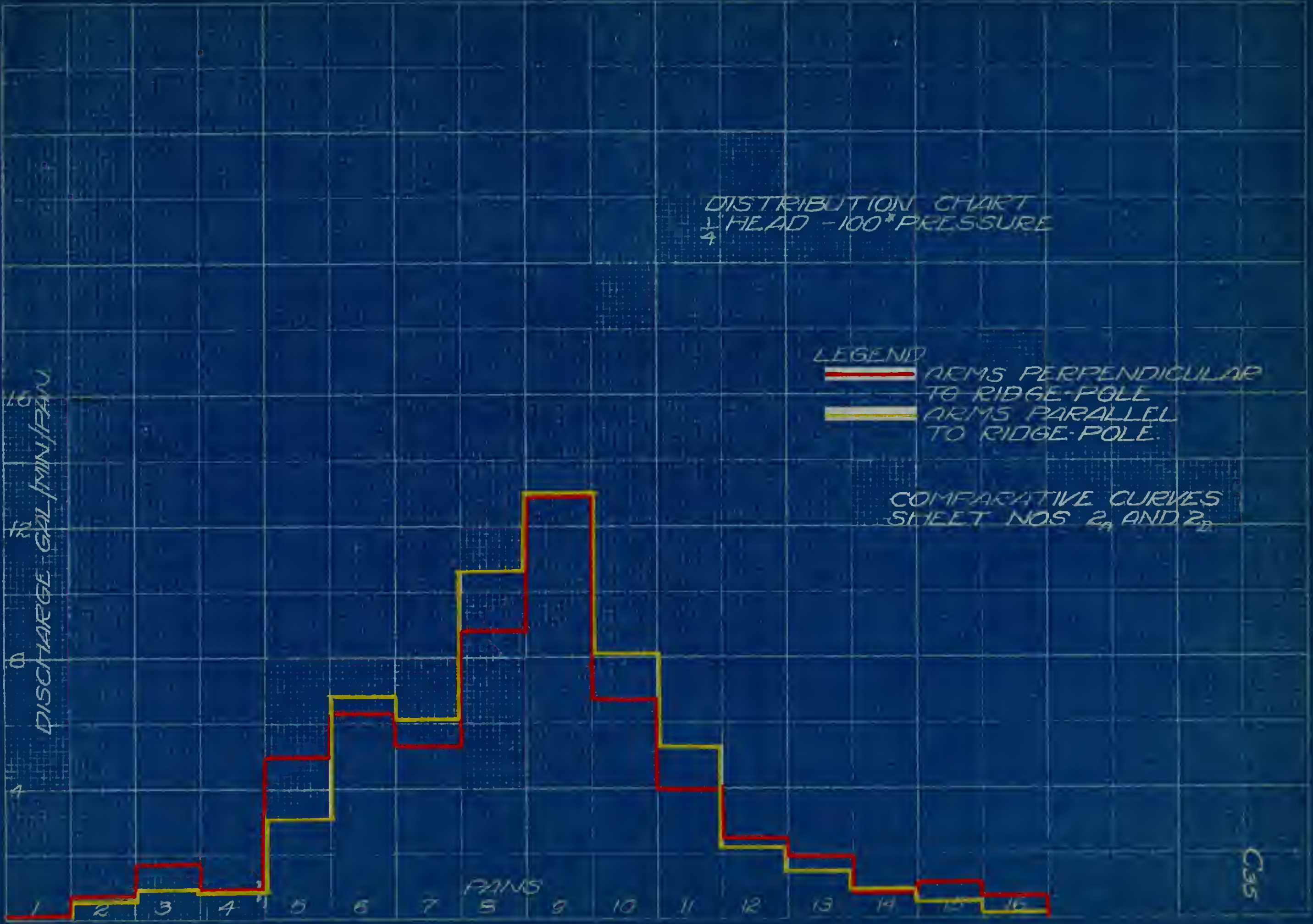
UNIVERSAL CROSS SECTION 453

C34


DISTRIBUTION CHART
$\frac{1}{4}$" HEAD - 75# PRESSURE

COMPARATIVE CURVES
SHEET NOS. 2_A AND 2_B

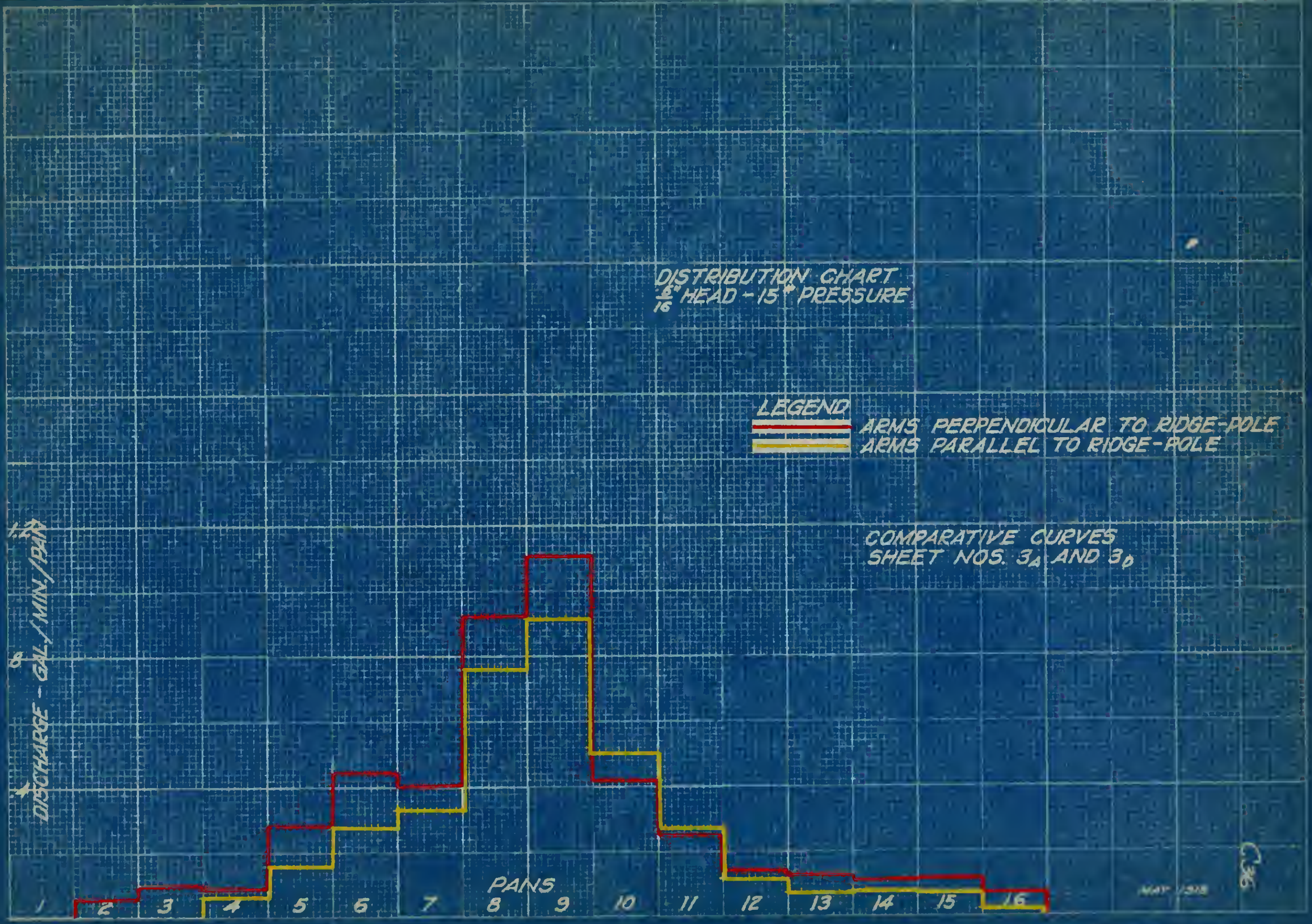
UNIVERSAL CROSS SECTION 455



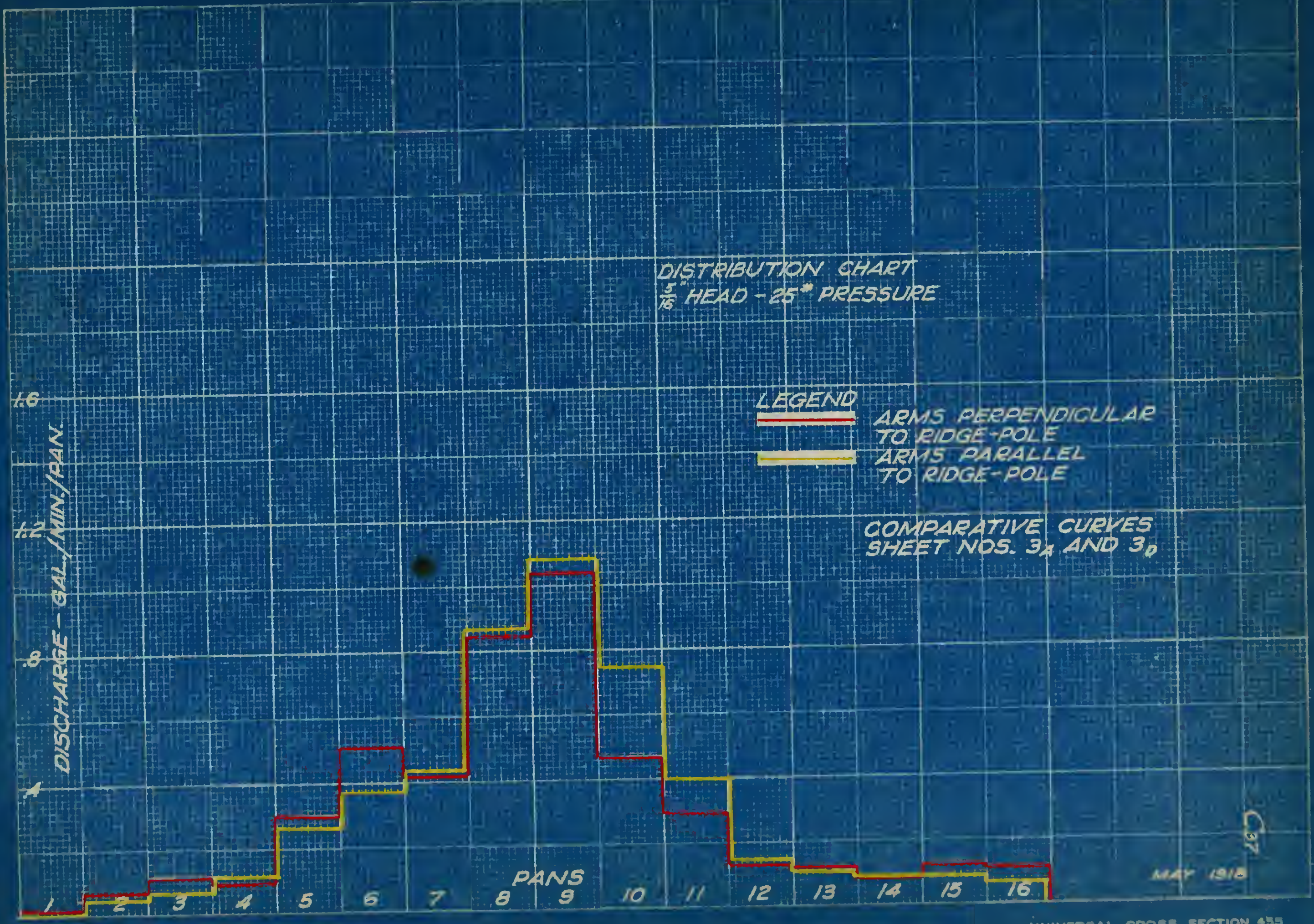
DISTRIBUTION CHART
$\frac{1}{4}$ HEAD - 100# PRESSURE

COMPARATIVE CURVES
SHEET NOS 2_A AND 2_B

C35


DISTRIBUTION CHART
$\frac{5}{16}$" HEAD - 15# PRESSURE

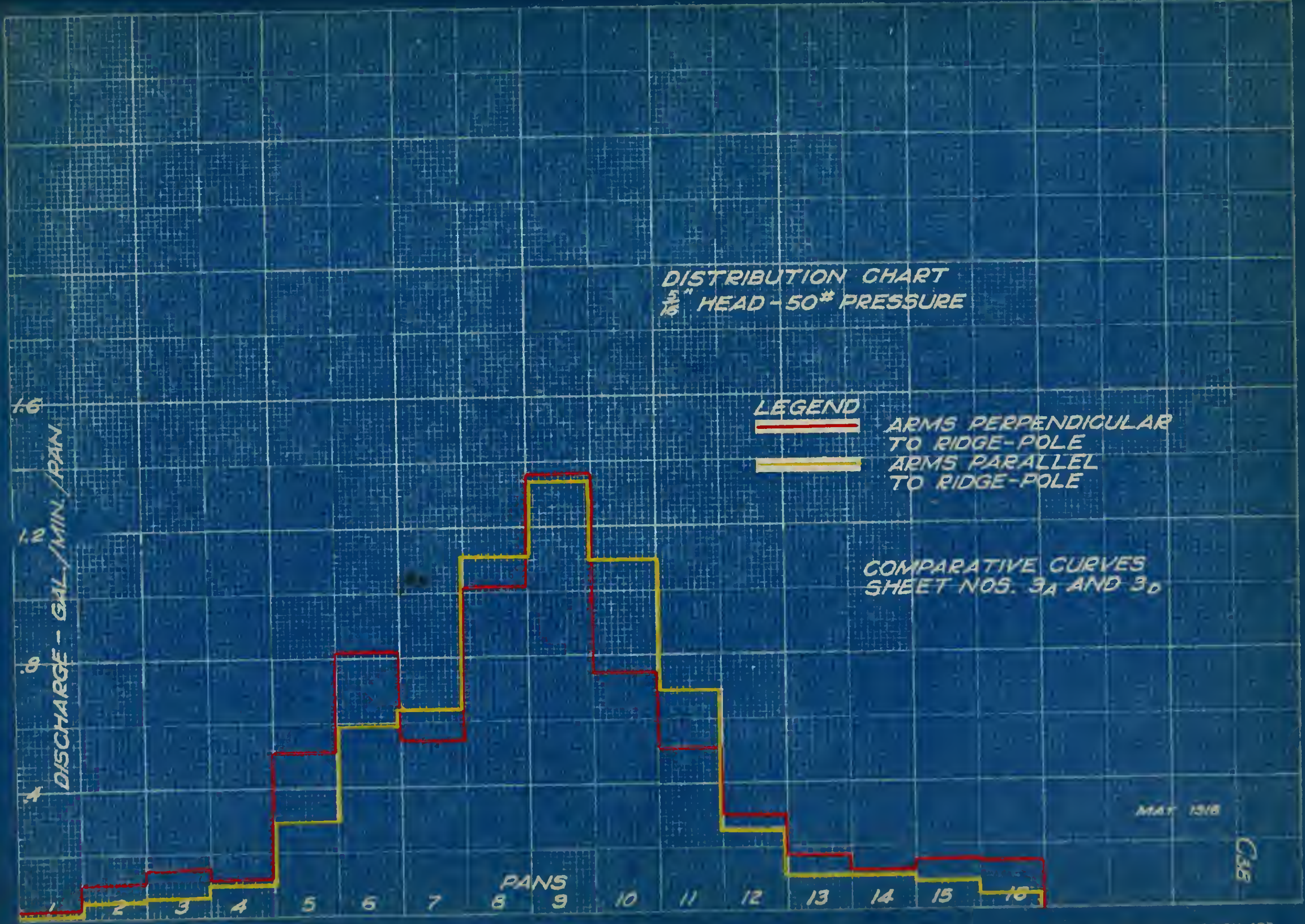
UNIVERSAL CROSS SECTION PAD



DISTRIBUTION CHART
$\frac{5}{16}$" HEAD - 25# PRESSURE

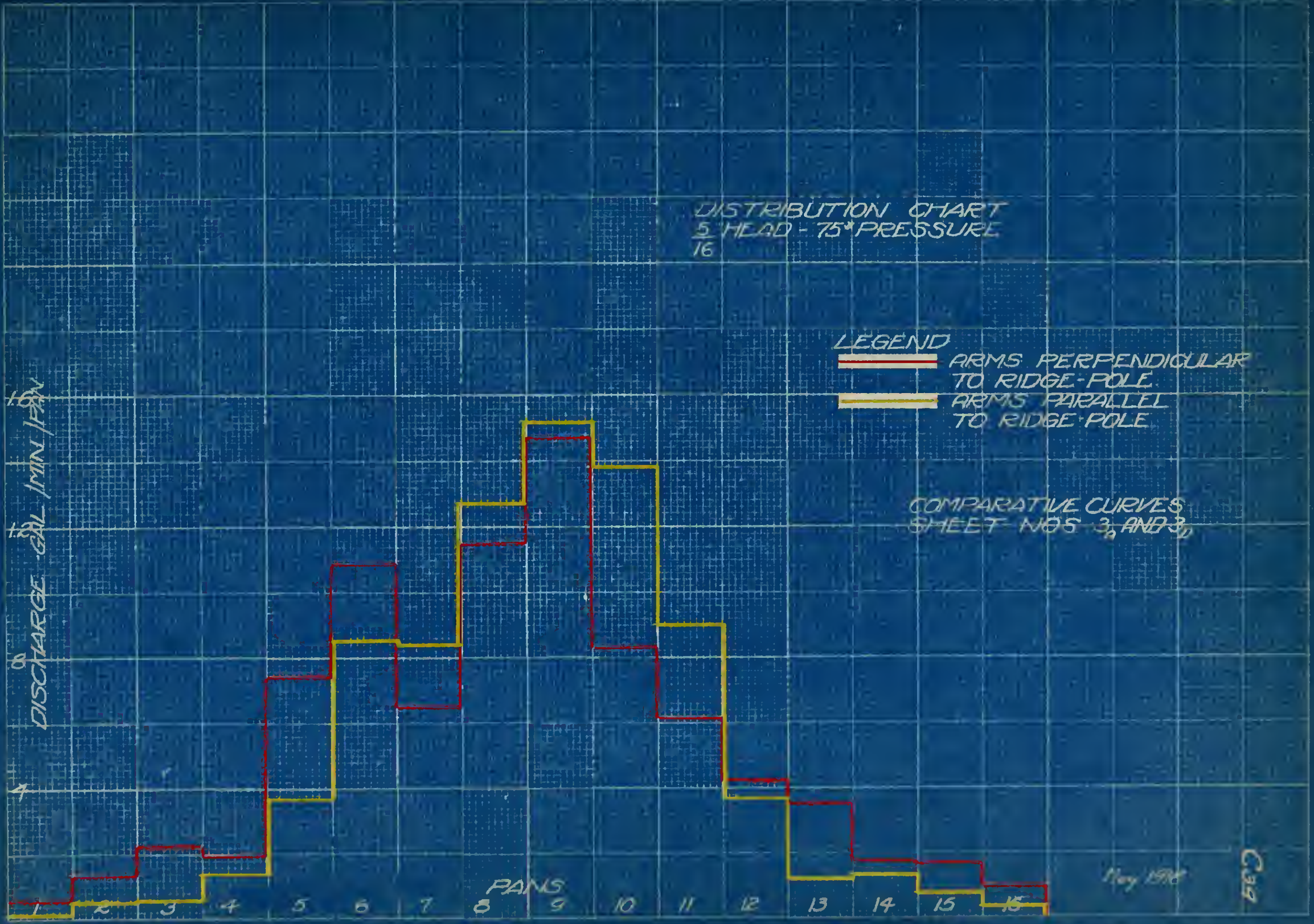
COMPARATIVE CURVES
SHEET NOS. 3_A AND 3_D

UNIVERSAL CROSS SECTION 455



DISTRIBUTION CHART
$\frac{5}{16}$" HEAD - 50# PRESSURE

UNIVERSAL CROSS SECTION 455

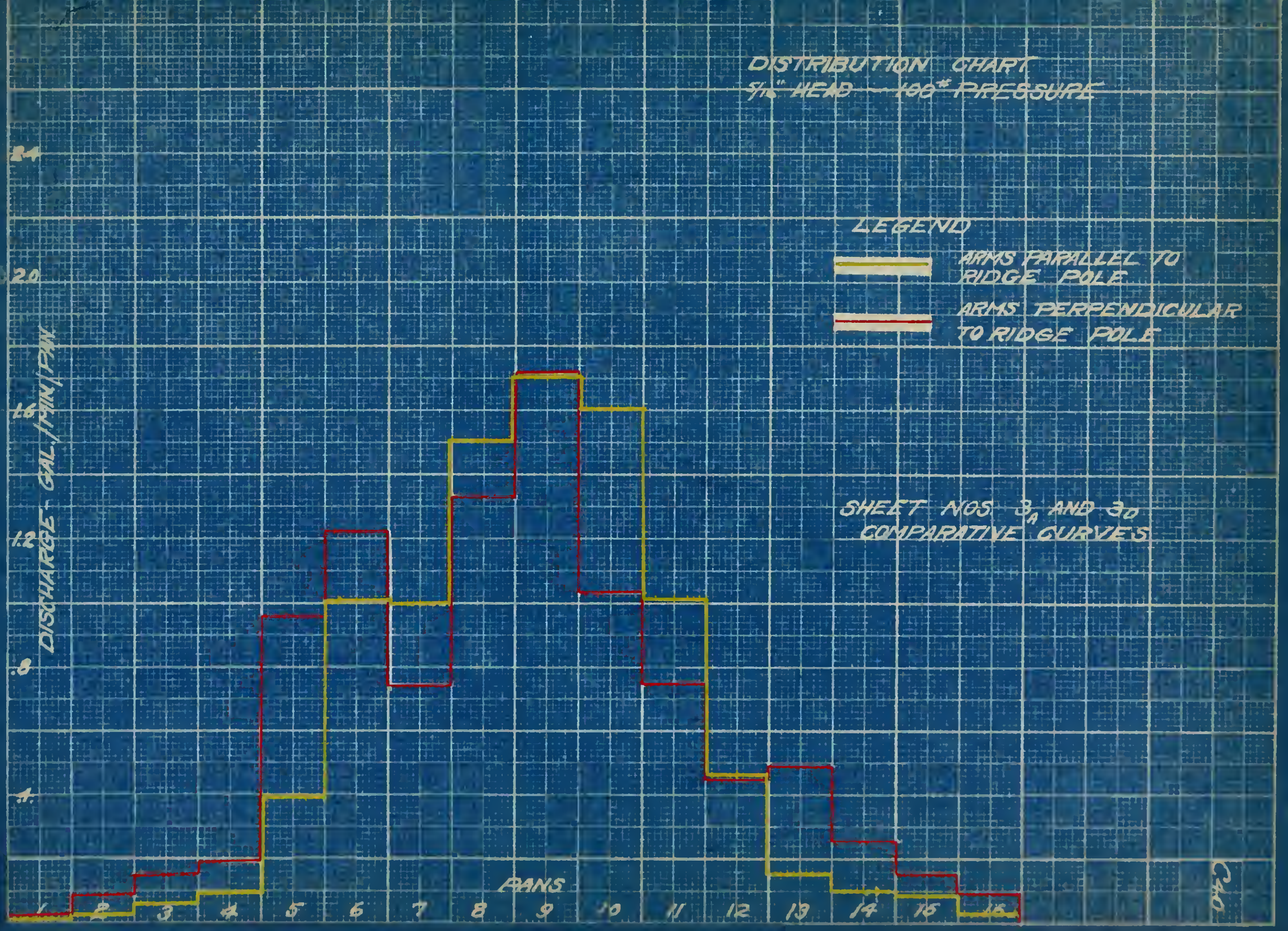


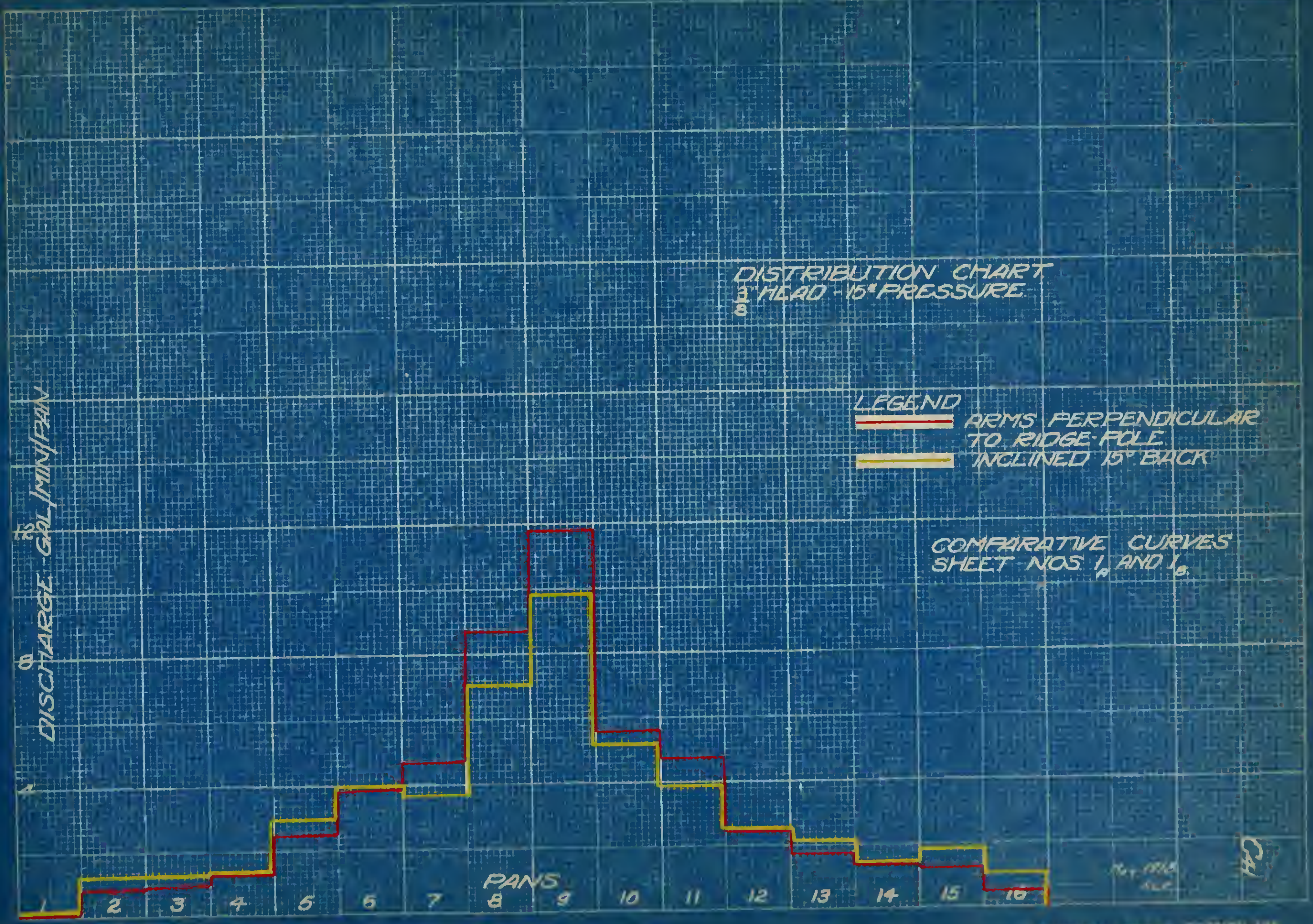
DISTRIBUTION CHART
$\frac{5}{16}$ HEAD - 75# PRESSURE

COMPARATIVE CURVES
SHEET NOS 3_a AND 3_b

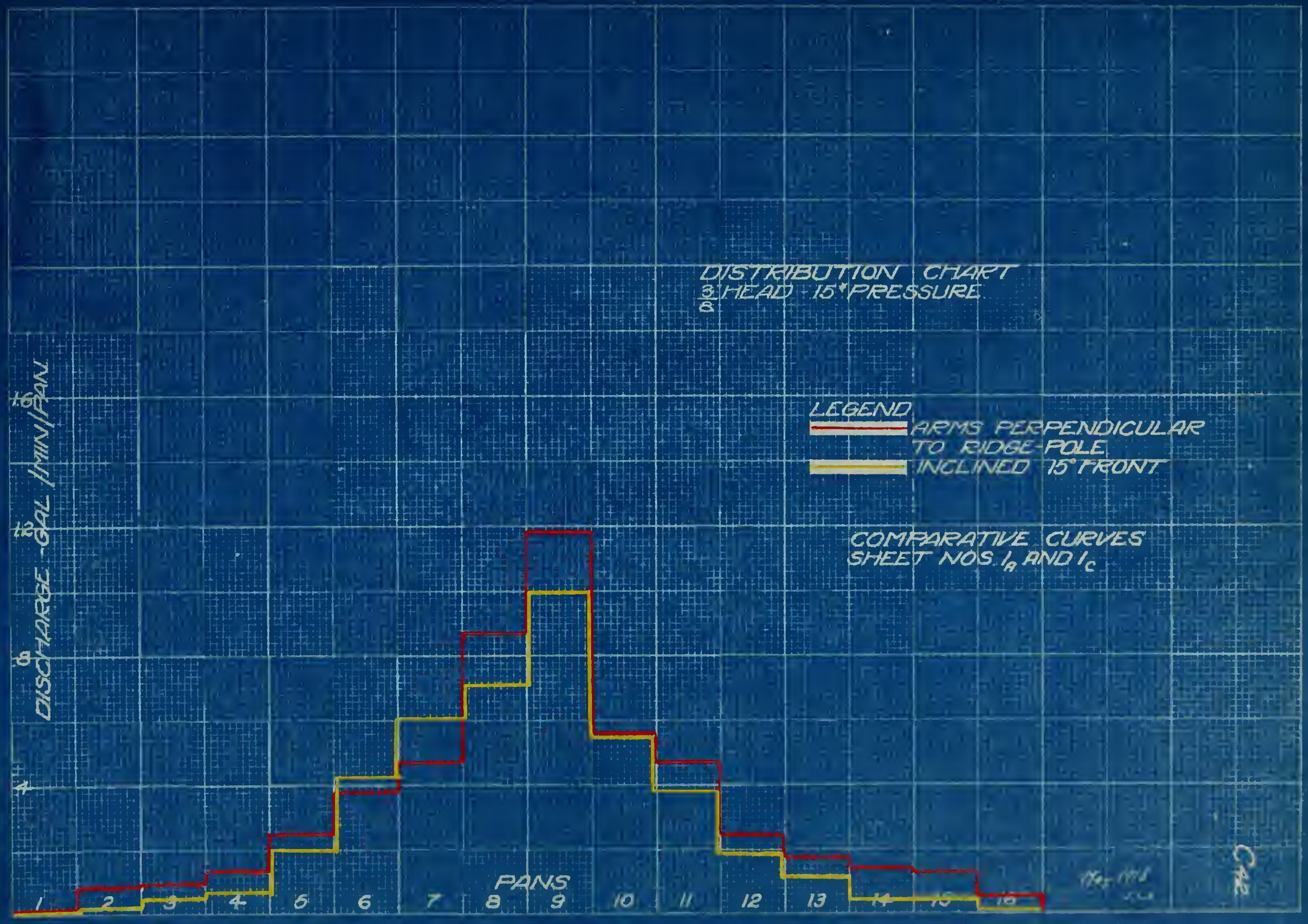
May 1918

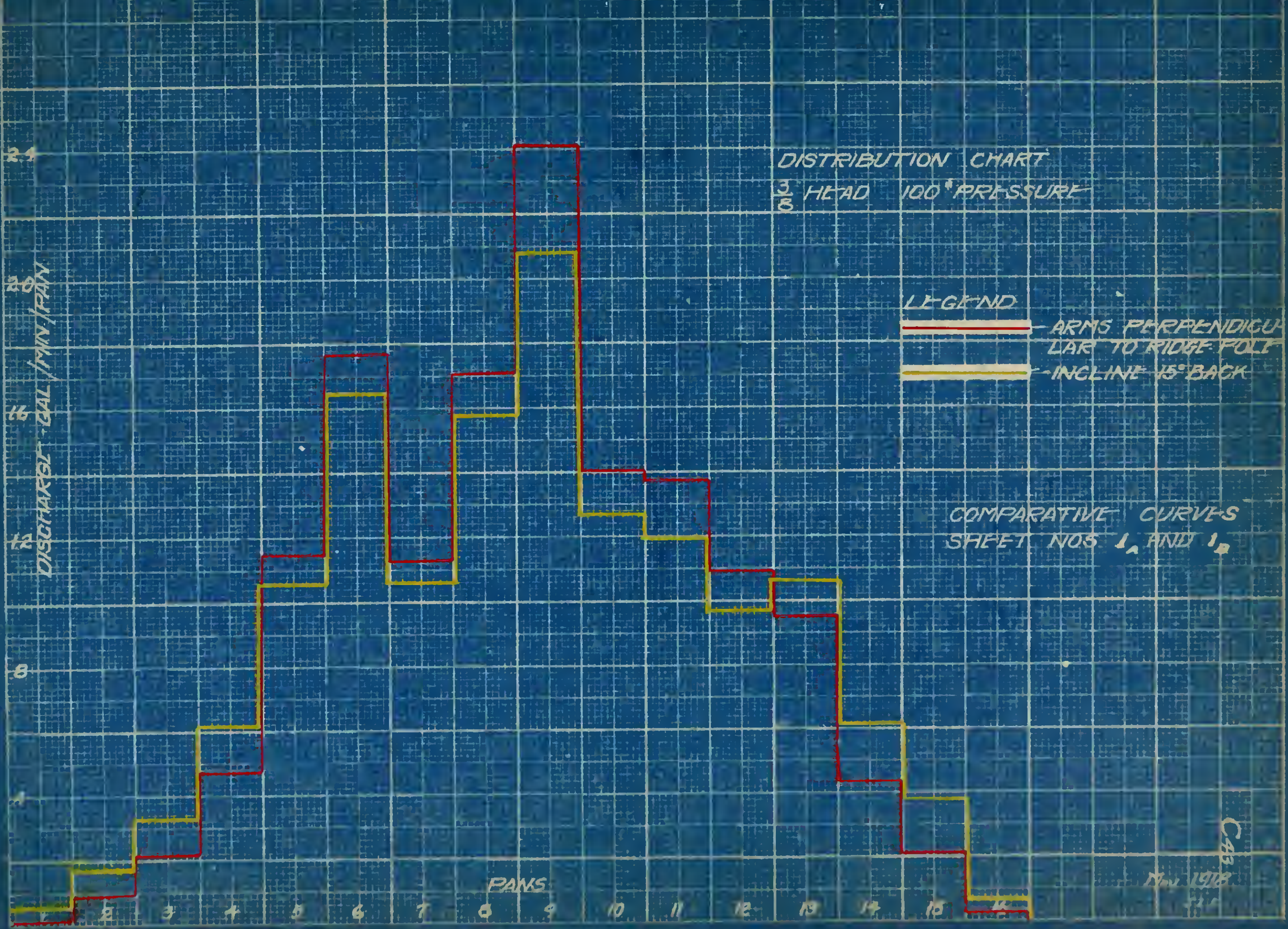
C39


DISTRIBUTION CHART
5/16" HEAD — 100# PRESSURE
LEGEND
ARMS PARALLEL TO RIDGE POLE
ARMS PERPENDICULAR TO RIDGE POLE
SHEET NOS. 3A AND 3D
COMPARATIVE CURVES
DISCHARGE - GAL./MIN./PAN
2.4
2.0
1.6
1.2
.8
.4
PANS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
C4.0



UNIVERSAL CROSS SECTION 419


DISTRIBUTION CHART
3/8 HEAD 15# PRESSURE
LEGEND
ARMS PERPENDICULAR TO RIDGE-POLE
INCLINED 15° FRONT
COMPARATIVE CURVES
SHEET NOS. 1a AND 1c
DISCHARGE - GAL./MIN./PAN.
1.6
1.2
.8
.4
PANS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
C42
UNIVERSAL CROSS SECTION 455



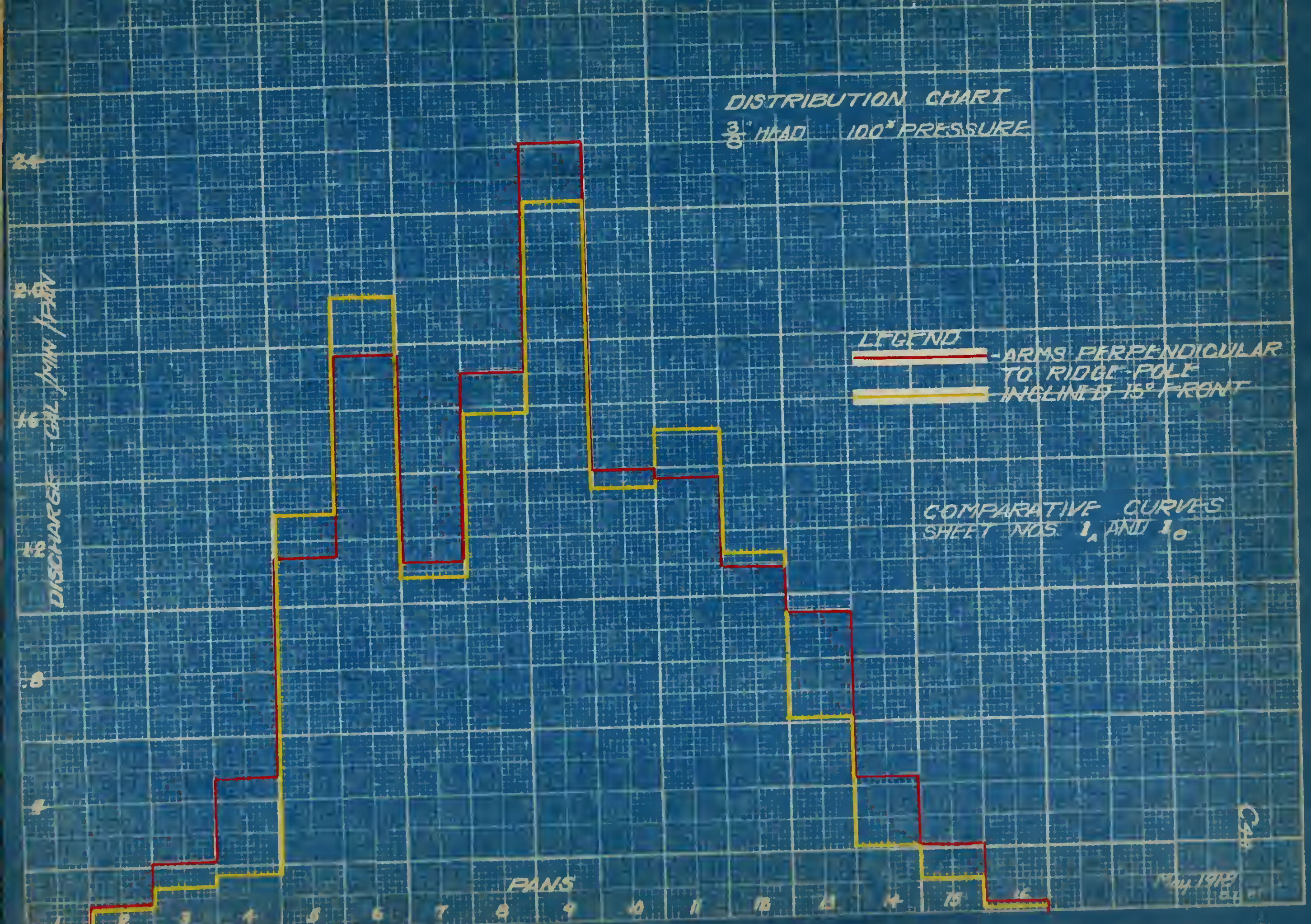
DISTRIBUTION CHART

$\frac{3}{8}$ HEAD 100# PRESSURE

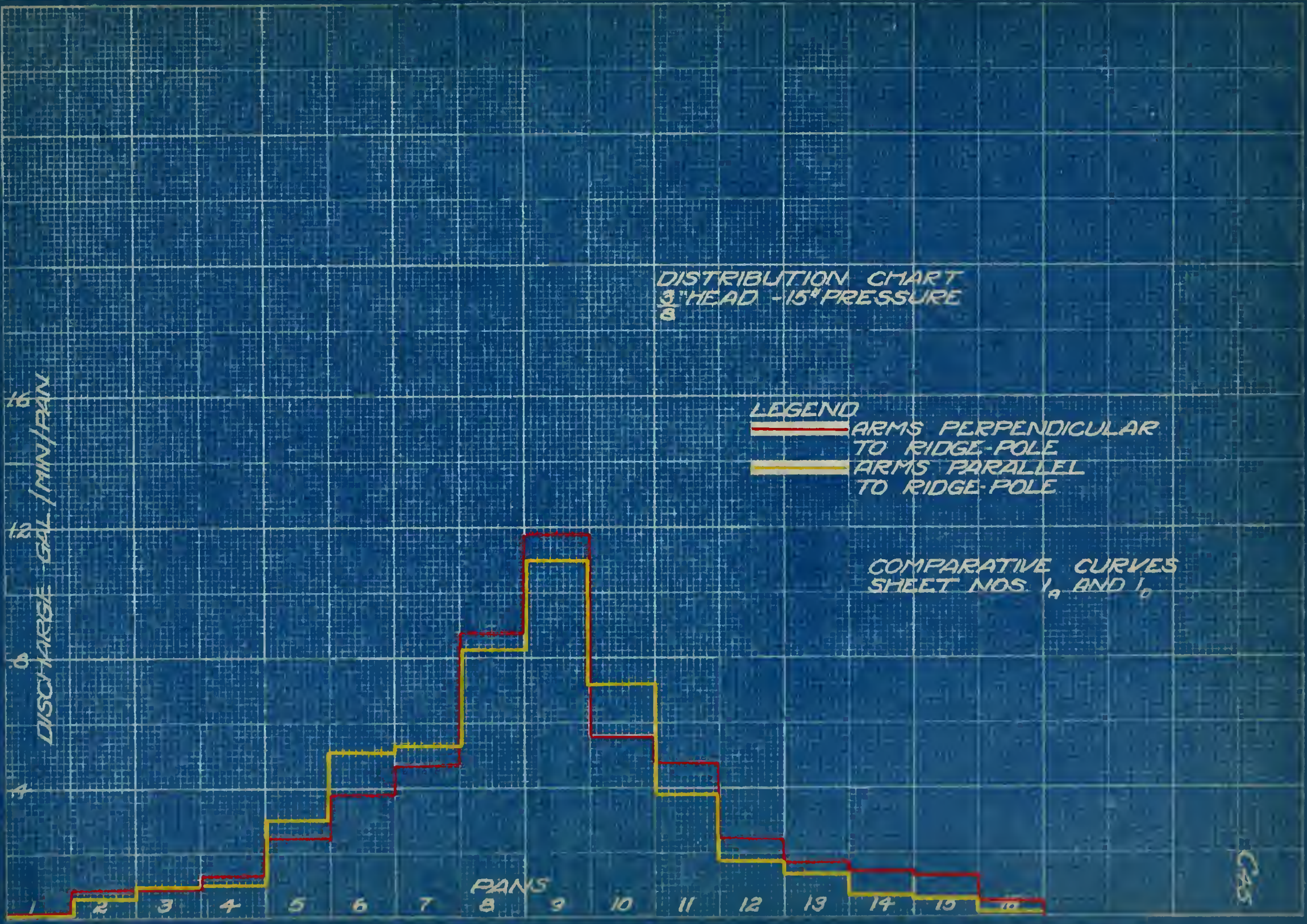
COMPARATIVE CURVES
SHEET NOS 1_A AND 1_B

C43

Nov 1918



UNIVERSAL CROSS SECTION 451



DISTRIBUTION CHART
$\frac{3}{8}$" HEAD - 15# PRESSURE

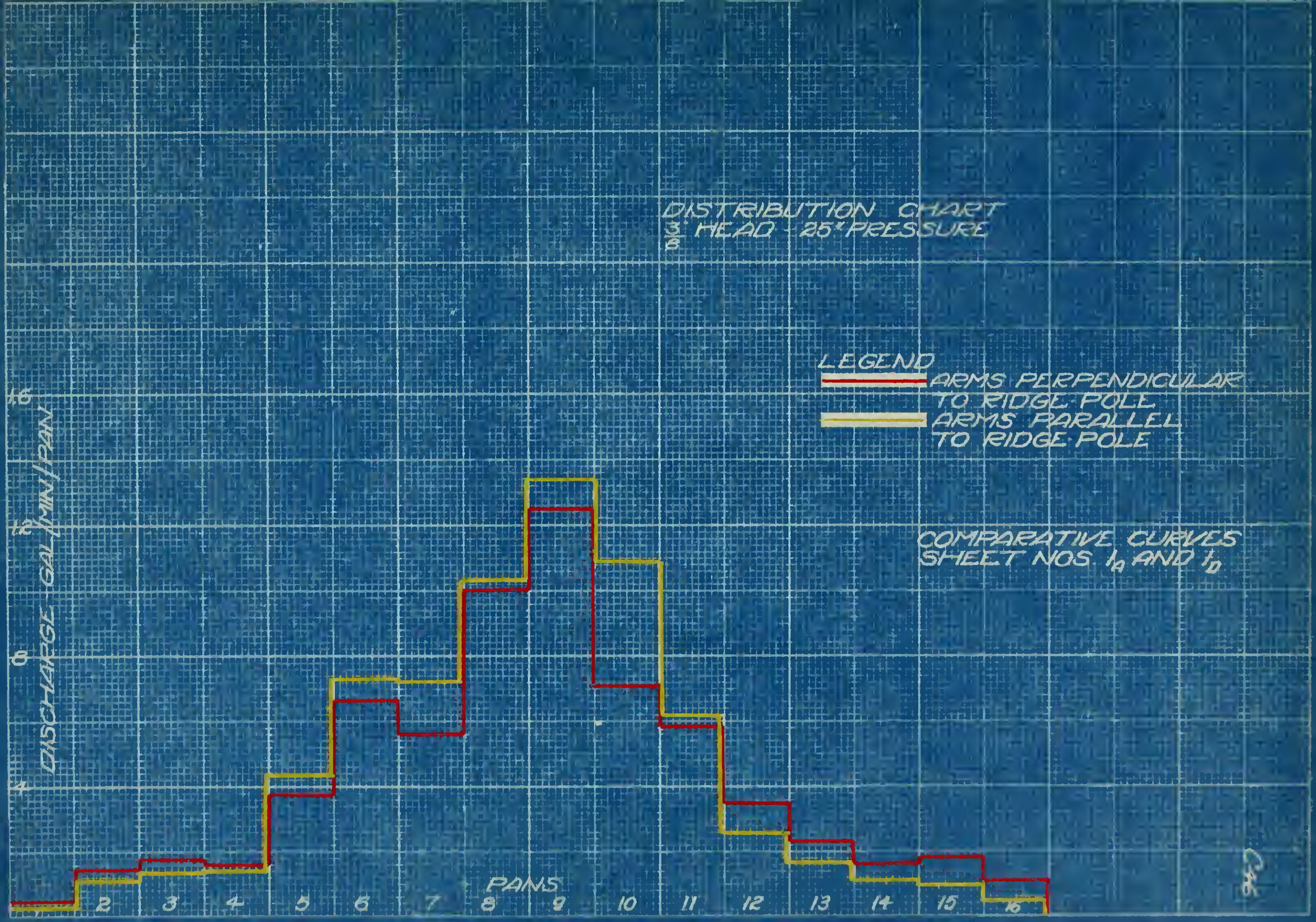
LEGEND

🟥 ARMS PERPENDICULAR TO RIDGE-POLE

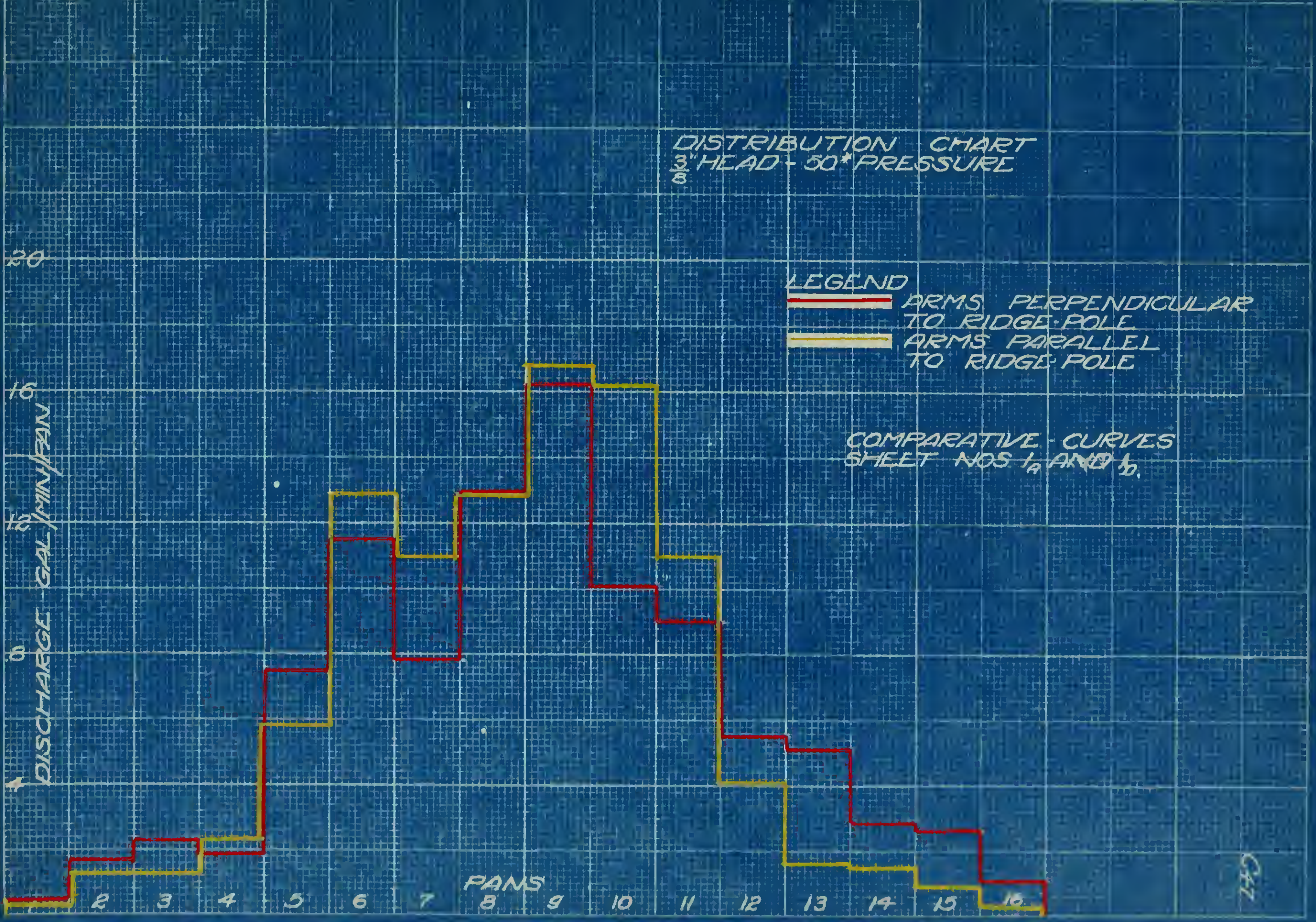
🟨 ARMS PARALLEL TO RIDGE-POLE

COMPARATIVE CURVES
SHEET NOS. 1_a AND 1_b

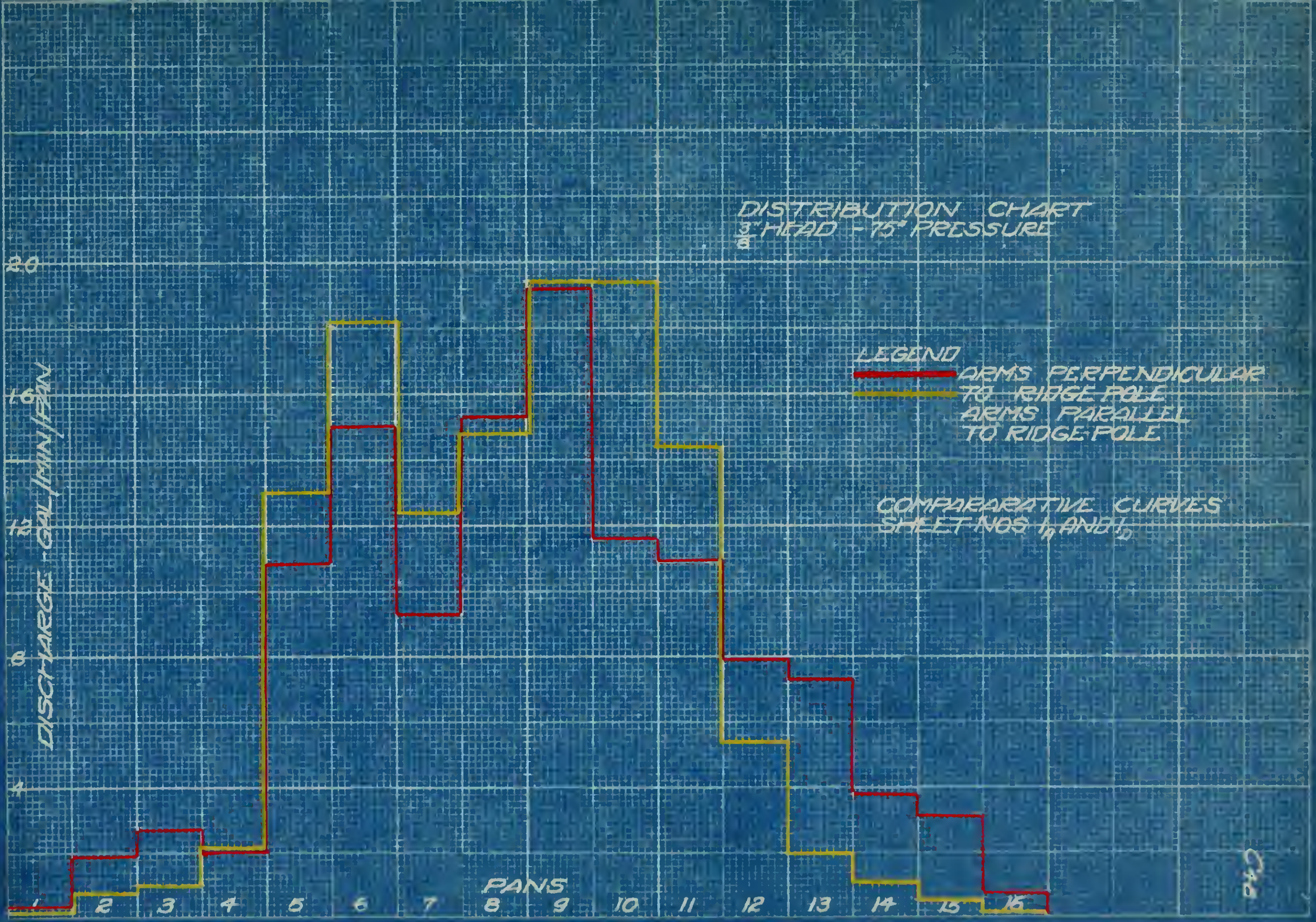
UNIVERSAL CROSS SECTION 455



UNIVERSAL CROSS SECTION 455

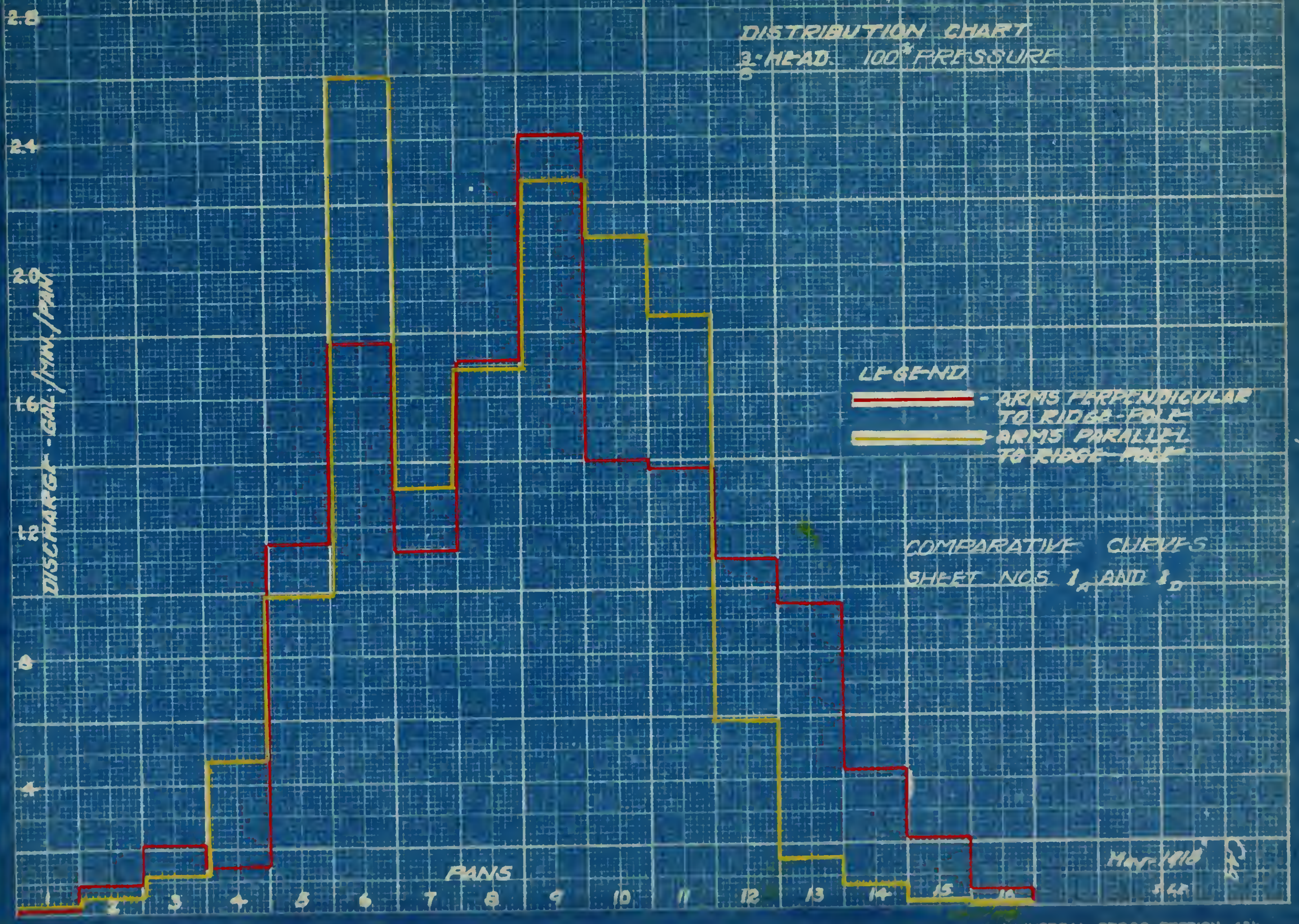


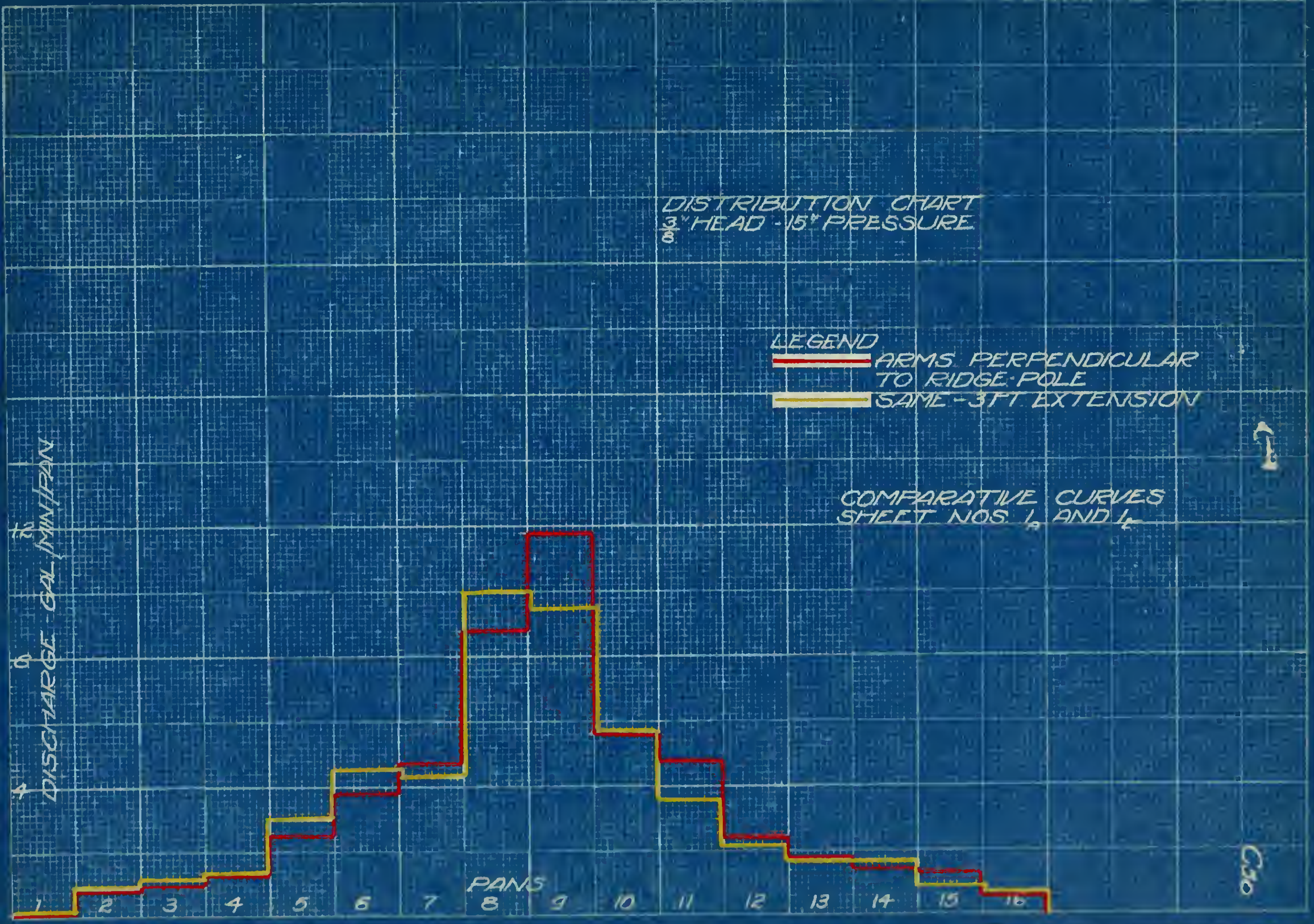
UNIVERSAL CROSS SECTION 443



DISTRIBUTION CHART
$\frac{3}{8}$" HEAD - 75" PRESSURE

UNIVERSAL CROSS SECTION 458


DISTRIBUTION CHART
$\frac{3}{8}$-HEAD. 100# PRESSURE
LEGEND
- ARMS PERPENDICULAR TO RIDGE-POLE
- ARMS PARALLEL TO RIDGE-POLE
COMPARATIVE CURVES
SHEET NOS 1_A AND 1_B
DISCHARGE - GAL./MIN./PAN
2.8
2.4
2.0
1.6
1.2
.8
.4
PANS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
May-1918
UNIVERSAL CROSS SECTION 431

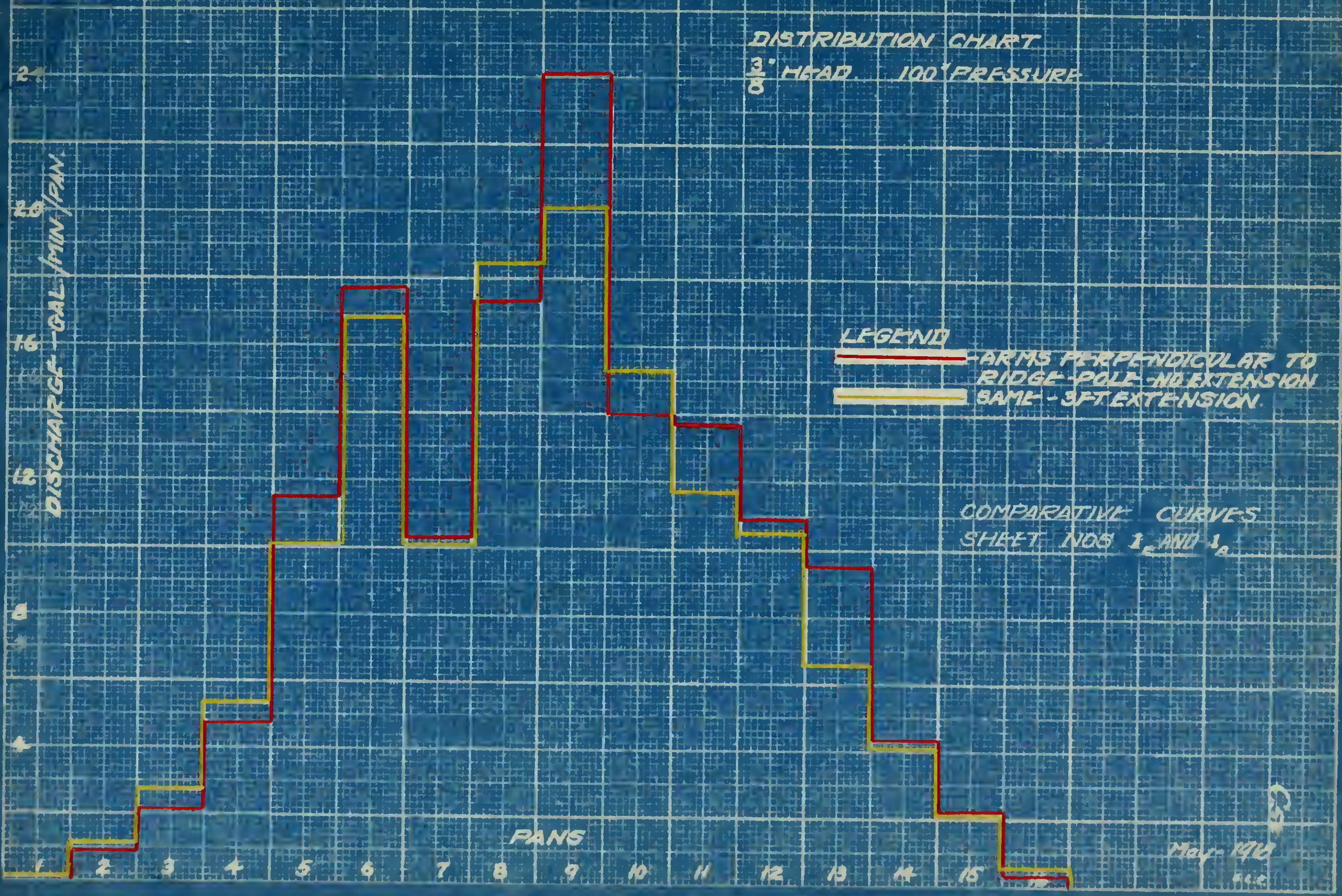


DISTRIBUTION CHART
$\frac{3}{8}$" HEAD - 15# PRESSURE

COMPARATIVE CURVES
SHEET NOS. 1_a AND 1_c

C30

UNIVERSAL CROSS SECTION 415



UNIVERSAL CROSS SECTION ,431